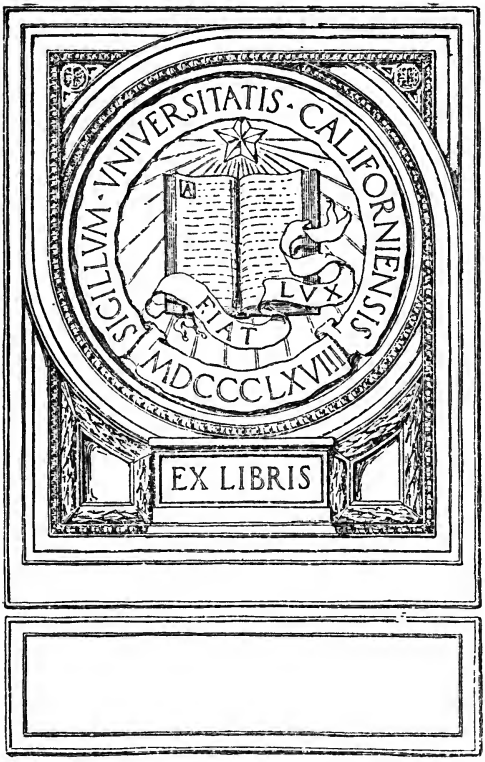
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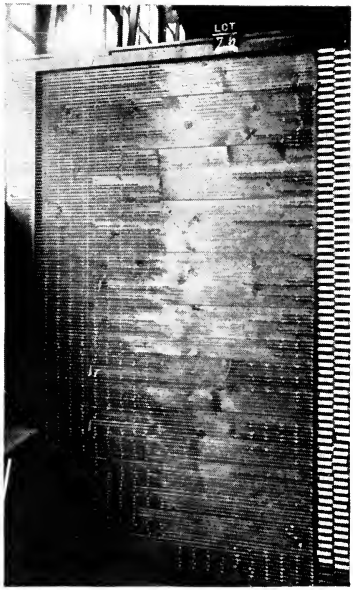

MAINTAINING a steady stream of quality production at low cost is the chief function of the factory. At the Hart-Parr plant, plan boards (upper right), keep part production regulated with assemblage (See Page 58). At the left, inspection of nippers by service test is shown. Below is the famous shortage-chasing department at the Ford plant

SHAW FACTORY MANAGEMENT SERIES

OPERATION AND COSTS

PLANNING AND FILLING ORDERS—COST-KEEPING METHODS—CONTROLLING YOUR OPERATIONS—STANDARDIZING MATERIAL AND LABOR COSTS

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PLANNING AND FILLING ORDERS

AUTHORITIES AND SOURCES

FOR PART I

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Chapter III. Contributed by Mr. Porter. Among the factories from which points have been drawn are those of Clark Brothers, Belmont, N. Y., Westinghouse Electric & Manufacturing Company, Tabor Manufacturing Company, and Felt & Tarrant Manufacturing Company.

Chapter IV. Contributed by Ford W. Harris, consulting engineer, formerly with the Westinghouse Electric & Manufacturing Company.

Chapter V. Contributed by Mr. Porter from his experience and investigations, in collaboration with Mr. Dennis. Plants from which material has been drawn are the Hart-Parr Company, Franklin Automobile Company, Cincinnati Shaper Company, Rathbone, Sard & Company, Thomas B. Jeffery Company, Home Furniture Company, York, Pa., Kohler Company, and others.

Chapter VI. Written by Mr. Porter and based on his own work, together with material supplied by Homer E. Dunbar, assistant chief engineer, Norton Grinding Company. The experience of the following plants, among others, is indicated: Norton Grinding Company, Kohler Company, Seymour Manufacturing Company, Detroit Lubricator Company, a New England machine shop, an eastern company manufacturing parts, and an Indianapolis saw company.

Chapter VII. Contributed by Mr. Feiker in collaboration with Mr. Dennis. Material was supplied by Mr. Feiker, Guy Cramer, C. B. Auel of the Westinghouse Electric & Manufacturing Company, H. M. Wilcox, formerly of Miller, Franklin & Company, Ford W. Harris, and the National Cash Register Company.

I

BRINGING PRODUCTION UP TO CAPACITY

THREE hundred thousand dollars had been invested by a manufacturer in equipment. His plant was in good condition, his bosses and workmen were efficient and diligent. An increase in demand for his product pointed the need for more equipment to the extent of one hundred and twenty thousand dollars.

His plant, however, was centrally located in a large city where every inch of space apparently was occupied. In order to handle the additional business, expansion seemed inevitable; and to expand meant to move.

At this stage he visited another factory and saw something of what could be done by accurately planning and scheduling work. So well did the new way promise that he decided to try it, and to that end, employed an outside engineer.

Orders previously had gone through from the front office directly to the foreman concerned. Each boss with his men had used their judgment and experience in carrying out their details of the work. No standard way of doing anything was recognized. Men came and went in every department. A job well done one week by a skilled man might be indifferently handled the next by a less capable workman.

Within six months, however, acting on the advice of the specialist, the manufacturer had increased his output about one-third. Some individual machines were doing double work, others twenty-five to thirty per cent more. These changes, chiefly in feeding the work into the operating departments, had cost him twenty thousand dollars; but they saved him outright

the expense of moving and were earning increased net profits every day.

Managers are likely not to realize the amount of lost motion involved in getting out their products until, like this manufacturer, they face some test. Then it becomes evident that the only logical way is to centralize the authority and responsibility for making maximum use of plant capacity.

Production is simply a change in the form of materials. This change, of course, involves planning, operation and search for more improved methods. When in the simple types of organization the workmen had to plan their jobs, get their own materials and tools, figure how long each task should take and which to do first, and keep their own time for cost-finding purposes, they failed individually to do themselves justice and were unable to work together in a truly organized way. So production and cost finding under the leadership of such men as Frederick W. Taylor has been specialized at every step. Someone has been relieved from the grind of forcing output and delegated to the task of betterment. The foremen and workmen also, generally speaking, have been freed from material chasing and from deciding and remembering what to do next and how to do it. All the planning and follow-up duties—the generalship of getting materials, tools and supplies to the machines and the workmen in single file at the proper rate of flow and bringing back cost data for the use of the sales department and the betterment men—have been centralized in a production or planning department. Instead of having each foreman's office a plan room unrelated to that of any other foreman, the work is distributed evenly from one office and the duties of follow-up and record are focused at that point.

The workman's duty, for which he is now trained, is to do what is put before him at the rate and in the way which has proved best. The improvement man's task is to find and set up better standards. The production department is expected to take the requirements of the sales department and match them as closely as possible with the capacity of the plant so as to keep the entire investment busy; to time and place every operation; to work out and indicate how it is to be done; to make sure that everything is on hand to do it, and thus avoid the cost of delays;

and so to assure a product the cost of which is known and is standard, the quality of which is right, and which is ready for delivery on time. From the costs which the production department's order forms, material requisitions and time cards enable it to tabulate, moreover, the staff men get indications which help them in finding ways to improve quality or cut costs.

To standardize the product as far as feasible has long been a practice among manufacturers, and interchangeable parts are an ear-mark of American machinery. Management is now accepting the opportunity thus presented and is doing the same thing for processes. In the most advanced organizations, it is subdividing factory work until each task is elementary and can be done in a standard way. No matter how labor may shift under ordinary conditions, the work will be done in practically the same way, with the same accuracy and at the same rate. In this fashion, it is taking the whole production order to pieces, and so timing and distributing the tasks that they will be finished simultaneously, ready for assembling at a previously fixed date.

HOW WORK CAN BE ADJUSTED TO KEEP THE ENTIRE INVESTMENT PRODUCTIVE

SINCE each unit of product has to bear its share of interest on the entire manufacturing investment, an idle machine always spells excessive costs. If some departments operate overtime while others idle, with the shift of the rush of work from the first to the second department at different seasons, poor distribution of tasks is even more evident. Figures representing idle investment in unused tools and equipment in any state or section, if they could be obtained, would be startling.

Lack of demand or failure to find buyers at the proper time is, of course, often at the bottom of the trouble. But much equipment, labor and material lie idle because adjoining departments are not so geared up as to produce a uniform stream of work. While one machine or department is gorged, another starves. In correcting these conditions, many problems of policy are encountered.

One plant had a total investment of eight hundred thousand

dollars and yielded a net annual output valued at nine hundred thousand dollars. Some of the departments and machine tools at certain seasons ran overtime and night shifts, while others operated only nine hours a day and many were not used on an average three days a week. The dividends, of course, were actually produced by the average investment in use, and diluted by the percentage of the capital idle.

Fortunately for this company it was supplying only about six per cent of the total market in its line. With this opportunity before them, specialists undertook to bring output in the lagging departments up to an even level with the most productive ones. They first made a careful analysis of the product by operations, followed by a detailed study of each machine and its capacity. Some of the machines they found to be so crowded that for eighteen months they would not reach work which was promised within the year. Others were so numerous or had such capacity that they could have done in four or five months all that they were delivering in twelve.

What machinery should be bought in order to secure level capacity and keep all the tools busy all the time, was the first problem. What output could be obtained after so doing, was the next, in which the sales offices were no less interested than the factory. To answer these questions took the time of several men for many weeks and cost the concern about fifteen thousand dollars. But the results warranted the expenditure several times over. It put the plant in balance. Some sixty-nine thousand dollars' worth of new equipment was installed. With this machinery to relieve the pressure in departments which had usually kept others waiting, it was estimated, the output would be one million, five hundred thousand dollars.

Sixty-nine thousand dollars in new investment thus served to duplicate two-thirds of the output derived from an earlier investment of eight hundred thousand dollars. Nor was either overtime or night-shift work involved in this result. The business had simply been over-invested by three hundred thousand dollars, which capital could have been made active by a small additional expenditure. And this lack of balance in equipment is the condition in hundreds of plants today.

In every such situation the first step, of course, is to plan and

schedule the production—to make use of the entire investment all the time. Not always, however, is the solution so simple and gratifying as in this instance. Limited markets often make it exceedingly dangerous to counteract over-investment by balancing up in equipment and throwing more product upon the sales department. An industrial engineer narrowly averted a disaster of this kind recently in a plant manufacturing machine tools.

After spending forty years in building the business up to a million-dollar output, its founder had left it to his two sons. It had always paid handsome dividends—originally because of certain patents and later because of high reputation in the trade. About six hundred thousand dollars was invested in it. Eager to forge ahead, the sons contemplated putting up new buildings and spending in all about four hundred thousand dollars additional, most of which they expected to borrow. A specialist was engaged to cooperate in planning the expansion.

"What percentage of your market do you supply with your particular line?" he immediately inquired.

Both young men confessed their ignorance on this point. At his suggestion, a search of records all over the country followed, including the government offices at Washington. The result was startling; sixty-three per cent of the demand in their particular line was already theirs. To expand their sales ten per cent further, the specialist advised, was the maximum the firm could expect, regardless of increased efforts.

So the first calculations involved in putting all the shop to work all the time and regularizing operation throughout the year, concern the sales department no less than the factory. It is the meeting ground of demand and supply. Fixing dates and schedules for production must be done by the two departments in cooperation.

ANALYSIS OF PRODUCTION SHOWS THE FACTORY WHAT IT CAN DO BEST

SUCH an analysis further involves trade questions when it takes up standard and special products and varieties of goods. Production naturally divides into standard and special

work. An automatic screw machine in a big plant may operate for a year on one size and type of screw; a bench hand in a neighborhood shop may never have two jobs alike. And between these extremes of absolutely standard and entirely special work every factory finds its place. It may make one uniform product composed of standard parts, or a variety of products made up of either standard or special units or both in combination. All that is necessary to success is that it do work for which there is a demand, and through monopoly rights and a clear field, enviable quality, or low costs, get a profitable price for it. Whether or not competition forces close watch on manufacturing costs, to centralize the planning and control will cut present costs and thus pay dividends.

So the trend is undoubtedly towards standard production, through which the one-time cost of plant, equipment and setups is distributed over more units of product. From this viewpoint, many factories make two or three times the variety they should for the volume they put out. They "set up" and "knock down" machine tools so often that their costs on every line mark it as a special and the workmanship is often inferior. Spoiled work and excessive investment in small tools further hamper their ability to compete in the market, while the time lost from actual production greatly restricts possible output. In such instances, the remedy is to do a few things well; and production analysis points the way.

Eighty-nine items were regularly made by one concern, the net annual profits of which averaged five and a half per cent. A study of the production and costs showed that many of the items had small sales and were profitless. In some cases, the article was being handled at a loss. A schedule was then made out. The number of items was reduced from eighty-nine to fifty-six and all departments were put on long runs. So greatly did this change decrease production costs that, notwithstanding some reduction in sales prices, the plant paid a profit of eleven and a half per cent the next year. This reduction in sales prices made possible by reduced costs also gave the articles such an advantage in the market that the volume of business more than doubled, again making possible additional economies in manufacture.

In making any units of small value it is especially important for the production heads to analyze their facilities and focus on the things they can do best. One concern manufactured about a thousand varieties of buttons. When the cost of irregularities in operation were summed up, nearly six hundred kinds showed no profit. With the planning and scheduling of production, some three hundred profitless varieties began to pay and another three hundred sorts were abandoned.

Forty to fifty per cent of the manufacturers in the middle ratings are struggling with a variety of output too great for their volume of sales. Managers of such concerns are merchants rather than manufacturers; the selling end of the business is using the factory as its servant without regard to true costs or full use of equipment. As compared with competitors who specialize, costs run too high for the quality produced. The factory is out of balance. Many of the largest and most profitable plants are built upon the program of small variety and large volume. Over against this, a policy of large variety necessitates small output and high prices, and so invites cut-price competition from producers who are willing to chance production in larger quantities. Sales managers sometimes have the idea that the larger the variety of items they have to sell, the better they can control the market. Matched against this point, however, is the powerful lever of low prices on standard lines. Standardized production has changed loss to profit in many plants which optional styles and special contracts were rapidly carrying toward the rocks.

To simplify the order work, cut out profitless varieties and options, take up lost motion, relieve manager and office men from constant friction with the manufacturing departments, and assist the foremen to keep their work in shape; to get accurate time and cost returns; to avoid delays and failures to discover shortages or incompleteness before shipping date; to know and use the shop's full capacity constantly, and to give the sales staff the lever of low prices in such cases as these is a reasonable expectation from properly organized production.

In reorganizing the work of the factory for positive promises and prompt deliveries, the first step, after lopping off special work and standardizing the product as far as seems wise, is to

determine exactly what labor, equipment and materials are at hand, on what work broadly they are to be used and what conditions are necessary to give a smooth stream of work which will keep all the forces steadily busy. A concern may, for example, manufacture electric motors, of which there are ten different sizes. Three or four years' experience has perhaps shown the average sale of each size to be one thousand annually. In normal times the natural thing then would be to schedule ten thousand motors as the task for the next year, with a leeway of perhaps two months for increased trade.

With this information, the heads of production make a complete analysis of the contemplated output as to different models, have all possible parts standardized and the operations to be done upon each laid out, calculate the quantities to be made each month and week, distribute the work over the forces available and supply the new equipment, material and men required for even production. They then set a schedule for each piece, with the aim of having so many motors ready for assembling and completed each week.

If the labor costs are available from past experience, the required labor in wages and men is easily calculated. The total number of hours allotted to the work, divided by the number of working days and hours indicates how many men to employ, and gives a basis for regularity in employment, with which labor costs in the long run are so closely concerned. Amounts of material to be bought and dates of material delivery are also on record or to be calculated. From these two factors the management gets a third schedule suggesting the financial requirements on various future dates—a matter of special importance to concerns that invest heavily for a short sales season.

This commonsense analysis of what is to be done toward the efficient distribution of tasks is the starting point for the manager in reorganizing the operation of his plant. In some instances engineering and mathematics are required; in others, nothing more than arithmetic and foresight. In the thousands of plants which work to special order chiefly, the problem is difficult, but has repeatedly been solved by readjustment of lines, discontinuance of the less popular specials, development of manufacture to stock and closer cooperation with the sales de-

What a train despatcher is to a railroad a production department is to the factory. Above is a view of the tool-production department for the Pierce-Arrow automobile. All scheduling, routing, and despatching of work is handled through the card system shown. Efficiency is increased by the sliding writing-shelf which makes it seldom necessary to move the heavy card boxes. Work requiring special attention is indicated by the bulletin board on the wall

Accurate records of production must be kept at the manager's desk and at the machine. In the manager's office of a stove company (above), the supply of material is kept three weeks ahead of demand by means of the schedule shown (See Chapter V). Under scientific management, orders, drawings and instruction cards are taken to each workman before the previous job is finished

partment on the special work. The result in every case is a better perspective over the work of the season ahead and a grasp upon the task day by day. The production superintendent knows as fully as trade conditions will permit what the output shall be by kind and size. Pieces and operations are standardized. Equipment and tools are balanced in quantity and standardized as to speeds, feeds, maintenance and supply. The purchase and delivery of materials is scheduled. The labor, finally, is assigned. The chief of production becomes a commander of known forces.

HOW THE WORK OF PRODUCTION IS SUPERVISED AND FOLLOWED THROUGH

IN the planning of this master-schedule, the heads of the business are concerned. The routine of carrying it out and shaping it to day-by-day sales and emergencies usually rests upon the production or planning department. Standards are furnished to this department by the improvement men. On the basis of these standards, the chief production clerk dates up the detailed schedules for work. When the time and rate have thus been determined, production clerks indicate on each order how the work is to be processed and routed from machine to machine, and dispatch the orders in proper succession. Foremen and executives are left free to do their real work. Reversing the old order, every man has a task ahead instead of being expected to hunt for another when one is completed. Each order takes care of the material and tools involved in its execution, so that the different elements are assembled at each focal point at the proper time, no matter how far one or another element comes. The production department also handles the follow-up on orders and becomes a clearing house for all records and statistics as to progress on jobs and the capacity of the plant to handle more work. It further receives and controls the finished stock, and collects the information from which costs and closer control develop.

How much of the work can be scheduled far ahead and reduced to a smooth routine depends on the character of the product; whether manufacture is to stock, what trade conditions

are and what emergencies appear. As unexpected orders come in and machines, materials or men fail to keep to schedule, the chief production clerk acts as a balance wheel hour by hour, finding a place for new orders, assigning more work to machines and men unexpectedly idle, untangling tieups, and maintaining an even flow of production.

In all this work, to which the following chapters will be given, the division of duties in (1) planning, (2) operating and (3) betterment prevails; and the central principle to which the organization is molded is, through foresight, as nearly as possible to keep all the investment busy all the time in the most profitable lines of manufacture.

II

RUNNING THE FACTORY BY SCHEDULE

FAILURE to schedule the work in the factory has not been due to lack of effort; a nicely ordered schedule has been the ideal of many managers. But the problem has often seemed too intangible to warrant organized effort. The daily or weekly conference of office and shop executives ran through the orders, secured dates from different foremen and blocked out the work ahead. But conditions were not standard, foremen rarely knew either the capacity of their men and machines or the detailed requirements of the order, and the schedule stood for little more than the output the meeting hoped to reach. When one or another department found that materials or supplies had not been provided, or for other reasons failed to make its dates, the management either accepted the situation to the detriment of the whole policy of scheduling or grew impatient and began to force the work in a way which merely made more trouble.

At the basis of such disorder is the fact that shop capacity is not known. Once the capacity of every department is determined, and brought up to the point where it can keep pace with the others, with a little leeway for safety, it is merely a matter of calculation to forecast deliveries, distribute the work evenly and supply the materials, tools, machines and men when and where needed.

In the most advanced shop practice, it is the business of the production, or planning department, to know scientifically, by machine ratings and time studies, just what the shop's capacity is, and to date up and lay out the work accordingly. No one

type of planning department is prescribed for factories of all kinds. There is the fully centralized planning section working as a unit under the scientific scheme of management in intricate

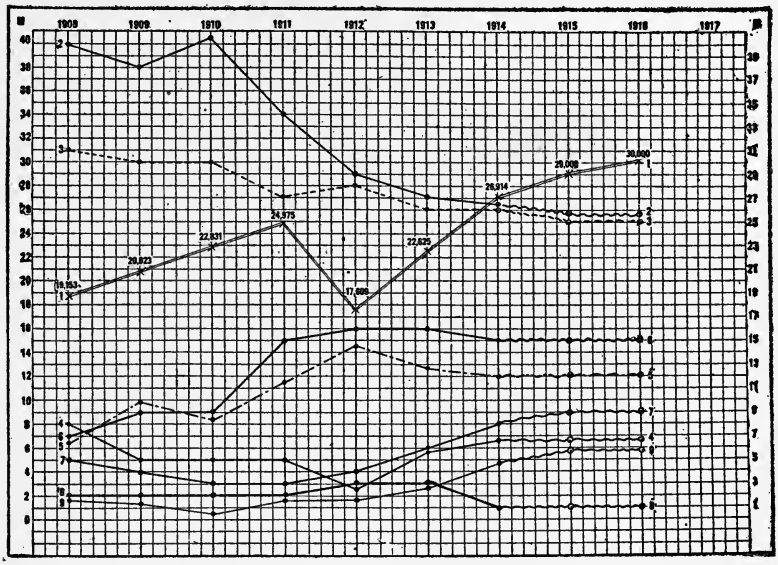


FIGURE I: Fluctuations in the annual gross sales of one machine (Line No. 1) and the percentage ratio which each size and style of that machine bears to the total gross sales are shown in this figure. Lines 2 to 9 are made up from past sales and future predictions. Line No. 1 is the basis for estimated requirements and the manufacturing order and is plotted from the actual sales. The waved line represents the sales manager's judgment for future sales based upon those of preceding years and general trade conditions

industries such as the making of machine tools. Another type centralizes the making of general schedules, but has subsidiary production stations in each main department to do the detail scheduling, routing and follow-up at that point. In some plants where the manufacture is less intricate, the detail planning may still be left in the hands of the foreman, with good results.

For the production department, independent of the investigators who help to determine plant and machine capacity, the organization in any case is simple. The chief production clerk must have a clear head as well as initiative and determination. He works with the superintendent of production and the sales manager on the major schedules, as well as directs operation day by day. With him are associated as many subordinates as

the work demands. These production clerks do the detail calculation, write up orders, attach instructions, and dispatch them on approval by the chief clerk, follow all operations that deviate from schedule and maintain the time, material and cost records.

The scheduling starts in advance of each new season and concerns itself (1) with the lump requirements of the sales department, known or estimated; (2) with the new business as it comes in. The making of schedules is simply a process of distributing the work to be done over the time allowed for it. After the general schedules are settled, the production department works out the department schedules to fit these requirements.

How these successive steps are taken, under principles which may well be applied in any shop, is well illustrated in the ex-

Mowing Machine Erecting Schedule No.1, November 1st 1914

Week Ending	Days		Size	1						2						3						Total	
	No. in Week	Cumulative	Style	A		B		C		A		B		C		A		B		C			
			Schedule	Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule	
				For Week	To Date	For Week	To Date	For Week	To Date	For Week	To Date	For Week	To Date	For Week	To Date	For Week	To Date	For Week	To Date	For Week	To Date	For Week	To Date
Total to Make					100		100		200		300		350		400		400		350		300		2500
Rate per day					62		31		25		31		25		17.85		25		20.83		17.85		
Days Required to Make					1.8		3.3		8		10		14		22.4		16		16.8		16.8		108.7
1915 January 9	6	6												71	71							71	71
16	6	12												107	178							107	178
23	6	16												22	200	120	120					142	320
30	6	24														80	200	58	58			138	458
February 6	6	30										40	40					92	150			132	590
13	6	36								50	50	110	150									160	750
20	6	42								100	150									48	48	148	898
27	5	47																		89	137	89	987
March 6	6	53				40	40	100	100											13	150	153	1140
May 1	6	101						72	172	97	300									87		169	2322
8	6	107						28	200											87	237	115	2437
15	6	113																		63	300	63	2500

FORM I: The total machines to be manufactured during the season are indicated in this erecting room or warehouse schedule. Sizes are numbered and styles are lettered. A separate schedule is prepared for each kind of machine made. In practice, the eye catches the numerals with greater ease if the cumulative totals are in red ink, and other figures in black

perience of an agricultural plant where operation is planned effectively but informally.

Every operation of manufacture is subject to schedule. Schedule-making begins with the desired output, based on the season's estimated sales, for on the probable sale of its product depends

the activity of the whole plant. Rearrangement and compromise between shop capacity and trade requirements will here be necessary. The schedule for the assembling room comes next. Whatever output has been forecasted must be accommodated on the assembling floor, or in the factory making to stock, in the warehouse. To blunder at this point involves alternate idleness and congestion in assembling, storing and shipping. Then come the schedules for the various processing departments. Each department must of course produce each day its share of the output to meet the assembling room schedule. Fourth in line are the schedules for the different originating departments, foundry, blacksmith shop and wood shop. These in turn must regularly deliver the proper materials to the processing departments. The final schedule is that for purchasing. Stock needs are of course supplied according to the maximum and minimum limits of the inventory cards. These limits, however, must be varied day by day. Every other class of material must be tabulated and pur-

Schedule Calendar.

Week		Days	
Beginning	Ending	In Week	Cumulative
January 4	January 9	6	6
1915 11	16	6	12
18	23	6	18
25	30	6	24
February 1	February 6	6	30
8	13	6	36
15	20	6	42
December 6	December 11	6	280
13	18	6	286
20	24	5	291
27	31	5	296

Mowing Machines to Be Manufactured Season 1915

Sizes and Styles	Quantity to Manufacture	Piecework Price of Each	Total Labor Cost
Size 1 Style A	200	$ 4.00	$ 800.00
B	200	8.00	1,600.00
C	400	10.00	4,000.00
Size 2 Style A	600	8.00	4,800.00
B	700	10.00	7,000.00
C	800	14.00	11,200.00
Size 3 Style A	800	10.00	8,000.00
B	700	12.00	8,400.00
C	600	14.00	8,400.00
Total	5,000		$54,200.00

FORMS II and III: In planning the work for the year, a schedule calendar, such as that shown at the left, is valuable in determining the maximum number of days which the factory can run. Quantities and labor values of machines to be made are recorded on the form at the right

chased in the proper amount for delivery to meet the working dates. In the plant making to order, similar schedules will be made at short intervals, and it is equally important to have at hand such data on material and capacity that the work can be promised intelligently and dispatched at once.

The management, therefore, will consider first the output schedule based on sales estimates, modified in the preliminary

conference by the production manager to conform as may be practicable to conditions of economical manufacture. As a basis for the sales estimate, the sales manager uses the order data from previous seasons (Figure 1).

Date

Machine Double Hd Planer No. 389 from Nov. 6, 1913 to June 27, 1914 Operation Plane

Catalog Number	Workman's Number	Hours Worked	Pieces Machined	Piece Price per 100 Pieces	Total Cost	Pieces per Hour	Earnings per Hour
1262	821	49	48	33.00	15.84	.98	32.4
420	821	47	37	40.00	14.80	.79	31.5
271	821	222	151	40.00	60.40	.68	27.2
1008	821	348	215	50.75	109.11	.62	31.4
262	821	682	482	40.00	192.80	.70	28.2
1566	821	268	79	100.00	79.00	.29	29.5
		1619	1012	Av. 46.63	471.95	Av. .62	Av. 29.2

Summary

Highest Average Earnings per Day $324 Working Hours 1839 Season's Requirements 962

Lowest Average Earnings per Day 272 Hours Actually Worked 1619 Spoiled after Planing 50

Difference 52 Hours Lost 220 Total to Be Planed 1012

FORM IV: Analysis of a single machine's output, showing that the piecework price must be adjusted, that the machine operated only eighty-eight per cent of the time, and that it was worked eight days making up for spoiled work, are details covered in this form,—all of which suggests the need of an adequate remedy. The maximum department capacity can be accurately forecast through the use of a series of such charts

The estimate of sales for the ensuing year is traced on the chart (Figure I) in pencil. Later the actual sales are lined in with ink. Compared year after year, the two lines make an interesting study. Such a chart is made for each line manufactured.

HOW THE MANUFACTURING ORDER IS DIVIDED AND SCHEDULED PENDING CORRECTION OF ESTIMATES

AFTER the first line of products is estimated by the sales manager for each variety and size of machine, and upon thorough discussion, is finally approved by the heads of the business, the other lines, numbers two to nine (Figure I) are also extended by him. The charts are then turned over to the office manager to be tabulated by quantities and handed back to the sales manager for his estimated field inventory, or "carry over." After he has deducted his estimated stock on hand at

the various branches and agencies from the estimated requirements, the sales manager will put the remainder (that which is to be manufactured), into the form of an order. "Manufacturing order No. 1," as it is called, then goes to the production manager, with the understanding that approximately only one-half of the order will be scheduled until later in the season. Before it is necessary to schedule the second half of the order, the sales department will have ascertained the actual sales for the past season, together with the actual inventory of machines left on hand. The original manufacturing order can then be revised as may be necessary.

With manufacturing order No. 1 goes an order for the various attachments or extras entailed. The method of estimating already indicated determines the quantities. For each kind of attachment to each type of machine, a chart similar to the first is made. One chart is devoted to "tops" for automobiles, one to "canvas covers" for harvesters, one to "binders" for headers, one to "tenders" for engines, one to each kind of "stacker" for threshers. Throughout, these attachment estimates are handled in exactly the same manner as the machine estimates.

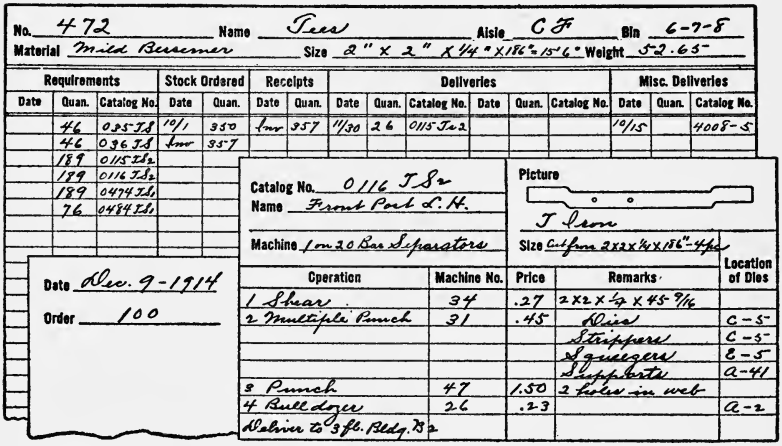
After receiving manufacturing order No. 1, the manufacturing department first makes up a finishing or warehouse schedule (Form I), for the total number of each machine to be manufactured during the season. At this point, it is essential to standardize operations and determine with accuracy the capacity of the plant. The most important questions to be considered are (1) the maximum number of days which the factory can run during the coming season; (2) the number of men that can be employed; (3) the quantities and labor values of the machines to be manufactured; and (4) the labor conditions.

To determine the maximum number of days which the factory can run during a season, a calendar (Form II) should be made for the entire season, commencing with the date the actual manufacturing is to begin. If manufacturing is not commenced on all machines at the same time, a calendar should be made for each of the starting periods.

Next to be determined is the maximum number of men that can be employed. The working hours of the factory or department for a season, multiplied by what the records show to be

the maximum number of men employed in erecting or making any one kind of machine, will give the maximum hours which could have been worked. By deducting from this the actual hours worked, the time lost is obtained. Dividing the time lost by maximum hours which could have been worked, gives the per cent of time lost. If the hours worked, 296,703, be divided by 2970, the working hours of the factory, the result, 100, is the average number of men employed.

Past records of most factories show that the average earnings per man per day for any or all classes of labor, are about the



No. 472 Name Tees Aisle C F Bin 6-7-8
Material Mild Bessemer Size 2" x 2" x 1/4" x 186" = 15'-6" Weight 52.65

Requirements			Stock Ordered		Receipts		Deliveries						Misc. Deliveries		
Date	Quan.	Catalog No.	Date	Quan.	Date	Quan.	Date	Quan.	Catalog No.	Date	Quan.	Catalog No.	Date	Quan.	Catalog No.
	46	035 T8	10/1	350	Imm	357	11/30	26	0115 T82				10/15		4008-5
	46	036 T8	Imm	357											
	189	0115 T8													
	189	0116 T8													
	189	0474 T8													
	76	0484 T8													

Catalog No. 0116 T Sr
Name Front Port L.H.
Machine 1 on 20 Bar Separators
Picture
T Iron
Size Cut from 2x2x1/4x186"-4pc

Date Dec. 9-1914
Order 100

Operation	Machine No.	Price	Remarks	Location of Dies
1 Shear	34	.27	2x2x1/4 x 45-9/16	
2 Multiple Punch	31	.45	Rivs	C-5
			Strippers	C-5
			Squeezers	E-5
			Supports	A-41
3 Punch	47	1.50	2 holes in web	
4 Bull dozer	26	.23		A-2
Deliver to 3 fl. Bldg. 82				

FORMS V to VII: Record is kept of each machine part processed in the blacksmith shop, on the operation card shown (Form VI). Complete instructions are given to the workman by this card. Even dies are located to save time. The "size cut from" on the operation card is necessary for the storekeeper's record (back form). This record is filed according to sizes of stock and serves as an automatic inventory. The order slip (at the left, below) is made out for an economical run, attached to the operation card and placed in the foreman's desk

same for each year. The manager and foremen can anticipate an increase or decrease in piece or day wages and can take the change into consideration in determining the probable future earnings. Assuming that, on an average, earnings per day in a position will be the same for the coming season as they were in the past, then multiply the average earnings per man per day, $2.50 for instance, by the average number of men who can be employed, as 100. The product, $250, is the averaged daily wages of the maximum number of men, and represents the labor value of the maximum daily output.

Next to be considered are the quantities and labor values of the machines which will be manufactured. The quantity of each size or style of each kind of a machine (Form III) is multiplied by the piecework price (or the day-work cost for the past season), to be paid for it. The sum of the labor cost of making or erecting all these sizes is the total labor value of the season's total requirements of this particular kind of a machine. One reason for making this calculation is that the ratio of the various sizes or styles to the total of all sizes or styles is constantly changing, otherwise the average price for the previous year could be used. The other reason for getting the total labor value is to determine the number of days required to make the machines.

In Form III the total labor value of the machines to be made, $54,200, divided by the "average earnings of 100 men for one day," $250.00, gives the number of days required to make them, which is 217.

In the event that this number of days exceeds the "maximum number of days which the factory can run" as determined by the calendar (Form II), it will be necessary for the management to decide which of three things to do; to run the factory overtime, increase its capacity or reduce the manufacturing order. Which of these policies to adopt is a subject worthy of much discussion.

If the required number of days is less than the maximum number of days which the factory can run, one of two things must be decided; either to run the factory at its high rate or full capacity for the number of days necessary to manufacture the order and then "shut down," or run at a lower rate for the entire season, even though it be at a fractional part of the maximum capacity. If labor is scarce, the last policy is undoubtedly the best, though not the cheapest, as it requires fewer men and also preserves an organization for the following season, which may be a heavy one. If labor is plentiful, the first policy could be adopted, reducing the cost and giving a long time for repairs and renewals, or permitting an increase in the order later in the season should sales warrant it. This plan also gives the plant an opportunity to make some machines in advance for the following season. Under this method of scheduling the

factory is likely to fall behind only through the inefficiency of the men, which means a decrease in the average earnings, or a decrease in the average number of employees. This, of course, is the extent to which the schedule can assist the manager.

DECIDING WHAT SIZES AND STYLES TO MAKE FIRST

BEFORE scheduling the processing and assembling, it is of course necessary to determine what sizes and styles of the various kinds of machines are wanted *first*. This can be determined by comparing by months or weeks the records of shipping orders received over a period of years. From the standpoint of manufacturing costs, it is essential to consider the quantities in each run of the various sizes. Constant changing from one size to another does not necessarily affect the cost of erecting or finishing, but increases the unit cost in the originating and processing departments. Machines should, therefore, be scheduled in as large runs as seem feasible, without probable delay in shipping. By referring to Form I, it will be seen that in fifty-five days the factory will have produced a complete assortment of all sizes and styles of this machine. By reducing the runs from 200, 150 and 100, to 100, 75 and 50, a complete assortment of all varieties will be made available for shipment in twenty-eight days. Time against economy is often the final problem.

Last season's erecting schedule is the basis for determining the succession in which the various sizes or styles of machines should be made. For each size or style of machine manufactured in the past, a chart is made. This is used in criticism of the erecting schedule after the latter is made "in the rough" from the last season's schedule.

Storage capacity has an important bearing on the erecting schedule, both as to the rate per day and the date manufacturing can probably be commenced. The storage capacity of every branch house also has its effect on the situation.

With the erecting schedule decided on, the assembling schedule is next taken up. The method of determining factory capacity on this work is exactly the same as that used in determining

the erecting capacity. Since the work in assembling departments is practically all hand work, there is usually no question about capacity. The same forms are used for this schedule as well as the same order and rates per day as were outlined in discussing output. In other words, the assembling schedule is exactly the same as the warehouse or finishing schedule, except for the dates. These are set far enough ahead of the finishing schedule dates to avoid the possibility of production in the finishing departments falling behind the schedule for want of assembled parts.

Next in order comes the processing schedule. As in the other schedules, it is necessary first to ascertain the capacity of each processing department. This is usually based on the output of from one to five or six machines in a department. These machines may be special or standard. An analysis of their work individually (Form IV) will give the maximum capacity of each department. The requirements of the work and the dates when it should be started and completed at each point then follow in the same manner as in the erecting and assembling schedules.

HOW TO SCHEDULE THE OPERATIONS IN A SINGLE DEPARTMENT

IF, NOW, the plant has a full-fledged production or planning department or is organized along scientific lines, the department schedules will be developed in detail by the chief production clerk. His orders will appear on the plan board or in the individual order boxes in all the departments. His men will determine the succession of work at every bench and machine, together with the dates necessary to make the schedule. In the agricultural plant under discussion, however, the foreman in each originating department, as the foundry, and the blacksmith, sheet-metal and wood-working shops, plans his own work on the basis of the general schedule. Scheduling in the blacksmith shop may be taken as typical of the general method.

Orders come to the foreman far enough in advance so that he can plan his work at leisure and keep a task ahead for every workman. An operation card (Form VI) is made for each

machine part which originates or is processed in the blacksmith shop. These cards are filed in numerical order by part catalog numbers and carry such information as the catalog number, name, size and machine of which the piece is a part and the number of the parts used per machine.

A rough sketch of the part gives a general idea of its shape, though the part itself is made from a sample. The "size cut from" is the size of bar from which the part is made and is used in conjunction with the storekeeper's record (Form V), which is filed by size of bar.

The operation card is held in the active or reserve file, as the case may be, and used perhaps years. With the manufacturing record before him the production clerk or timekeeper takes from the file the operation cards for the parts in order as needed and fills in an order slip (Form VII) for whatever quantity economy and shop conditions indicate. This slip is clipped to the operation card and the pair are placed in the foreman's desk tray in order of dates when the parts should be completed. Every day the foreman goes over these cards, chooses the orders to be dispatched and places such cards in succession of processing on the storekeeper's desk.

Daily the storekeeper checks these orders with his stores record of bars (Form V). If the material indicated in the "cut from size" space is not available, he still has time to procure it or in exceptional cases, to take the matter up with the foreman, who can then re-schedule the work in order to keep his machines busy. Lack of material rarely occurs, however, as it is purchased to meet the erecting schedule, under delivery dates which make allowance for the rolling, loading and transportation from the source. The storekeeper now places the card in the "job file" at the extreme left of the space for the machine on which the first operation is to be done.

In this "job file" is a pigeon hole for each machine in the shop, large enough to accommodate a week's work and arranged by machine number to accord with the floor plan. At his leisure the foreman runs through these cards and rearranges them to meet the constantly changing conditions of the shop. The workman always finds his next task on a card at the extreme right. In a more highly organized shop this arrangement would be

determined similarly by the route clerk in the production department.

In this shop the assignment of work to the machinists is done by the timekeeper, to whom the workman returns the operation card and order slip for the job just completed. On the "daily time slip" the timekeeper indicates the hour. He then places the operation card at the extreme left in the pigeon hole for the machine scheduled to handle the next operation, or if the work is finished, destroys the order slip and replaces the operation card in its file. For each new job, he gives the workman the card at the extreme right of the proper pigeon hole and in its place files a time slip properly filled out. These time slips, because of their larger size, show just what machines are running and upon what they are working.

While a man is working on a machine part, the operation card stands in a small rack near him. From it the workman knows where to get the dies he is to use, the rate he will be paid for the operation and the machine to which the parts are to be moved when he has finished his work upon them. Where the production department centralizes the planning function, one section of the original order would result in the delivery of the proper tools to the machine and other parts of the order would carry directions to the trucker for moving the material to and from each machine.

As soon as the workman has been assigned his new job, the timekeeper computes the time worked on the job just completed, extends the cost and enters the details from the time slip to the manufacturing record, which is thus kept almost up to the minute for reference in the rearrangement of schedules.

The schedules in the other processing departments work out in the same general way, differing as to dates, character of work and other details. The broad idea, as in the most centralized production department, is to have a right place for every job handled, a responsible person to schedule it and a detail man to handle the clerical work, with a proper time and person to do it.

III

LAYING OUT AND ROUTING THE WORK

HANDING the new workman a specification for erecting a traction engine, the foreman in a well-organized tractor plant walked away. The newcomer was a good all-around mechanic, but had never worked on tractors. He of course stood about for a while, expecting that the foreman would soon return to start him in. Finally, as the supervisor gave no indication of such intention, the man went to one of his fellows near by and asked him how they began here. He was told to read the specification and get busy. Doing so, he was agreeably surprised to find his work clearly indicated step by step. All the parts needed to assemble one engine he found already at hand. His first task, according to the specification, was to check over these parts. When he had done this, he began to assemble them according to directions, and although he had lost much time before starting, he surprised himself and the foreman by finishing his first job within the time limit.

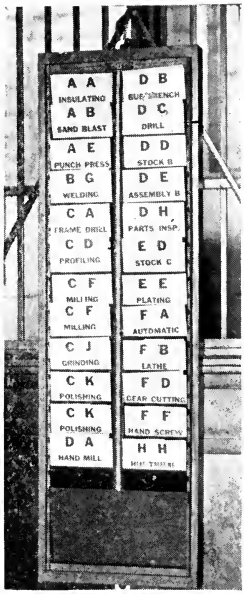
In shops where production is worked out on the principle of maximum use of investment, based on knowledge of capacity and continuous schedules of work at all points, every operation is laid out in advance with the clearness here illustrated. No longer are the foremen called together in the old-fashioned way to talk over each new order, to estimate the facilities of the shop for getting out the work and to say how soon they can promise delivery and what the cost will be. The old-time foremen essayed the best answer they could; and on the strength of their guesses, the order was accepted and delivery promised. Only by happy chance, however, was the outcome under this

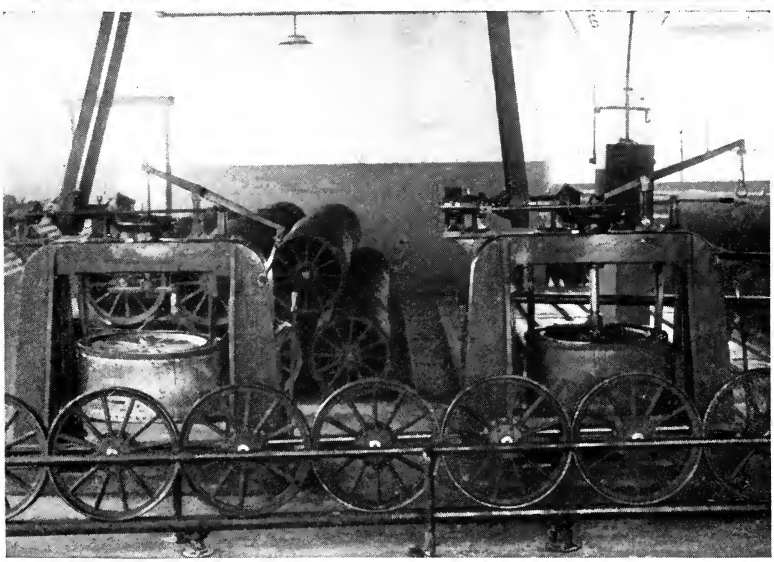
method satisfactory either as to cost or date of shipment. When an order goes into the plant that operates by schedule, the instructions on it are so complete that no planning effort is required of the operators; nor is there either delay or doubt in handling any detail of it. Costs, moreover, are very closely known in advance. As the architect pictures the entire building in blueprints and specifications, so that materials can be sawed to dimension at mills and quarries hundreds of miles away and still fit perfectly, so the work in such a plant is pictured and routed for the guidance of those who do it.

When the sales department gets wind of the order, the questions of cost and delivery come up. Office and shop confer and, consulting the general schedule of work, make their promise of delivery date. In this conference the sales department, the production department and the engineering department are usually represented. Thus the preliminary schedule precedes the detailed layout of the work. But before the work can be scheduled in full by departments, the order, together with the promise of delivery and probably specifications from the buyer, goes to the engineers. On the basis of their designs, blueprints and specifications, by which the order is split into its parts and the work on each part indicated in full, together with the requirements as to material, tools and dies, the production clerk will assign the work, issue explicit instructions to every operator concerned and make his detail schedules to assure completion of all parts in time for the delivery promised. The engineering department indicates what is to be done. The production department determines how and when. Thus the layout of the work is divided between the engineering department, which advises, and the production department which directs.

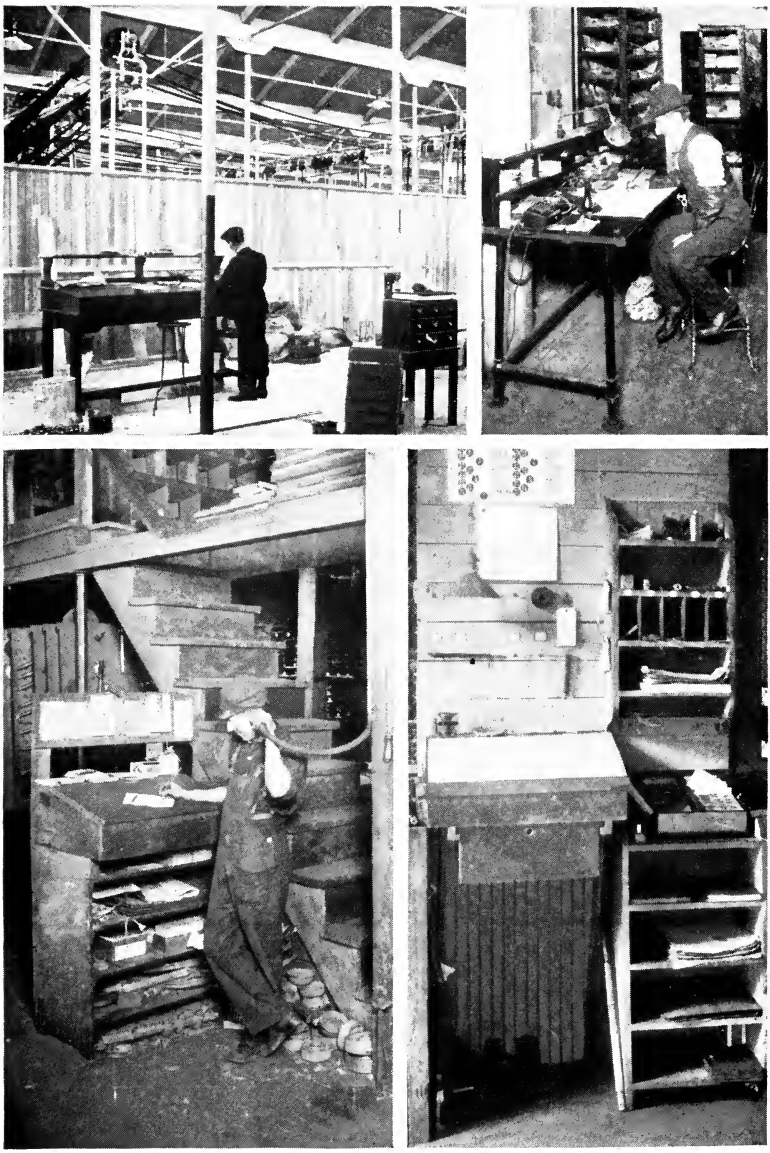
HOW AN ENGINEERING DEPARTMENT REORGANIZED TO HOLD DOWN LAYOUT COSTS

IN THE engineering office, the job is analyzed into its elements, and a bill of materials is prepared. Files are consulted for drawings and specifications covering standard work. Draftsmen supply detailed working drawings of new parts that are needed. Where required, the engineers add specification sheets.





Designating all departments by two-letter symbols aids accurate routing. Just outside of the elevator cages on each floor of the Dayton Engineering Laboratories (above), are racks of the "move" cards used to route material to the proper departments. At the Ford plant (below), wheels go from freight cars to paint shop as the balls are returned in a bowling alley



Four ways of filing orders in foremen's offices are here shown—cabinets, shelves and pigeon-holes help to systematize and speed order transfer. By means of clip-boards, orders are posted where they can be consulted quickly and also kept in good condition, with no unnecessary handling. Speaking tubes permit the manager to give verbal orders which can be confirmed in writing later

These plans go to the production clerk, who gets in touch with the tool maker and starts the work upon whatever new tools, jigs, dies and fixtures may be needed, as well as cooperating with the storekeeper in the supply of the right materials. By reference to the factory schedule he then establishes the best

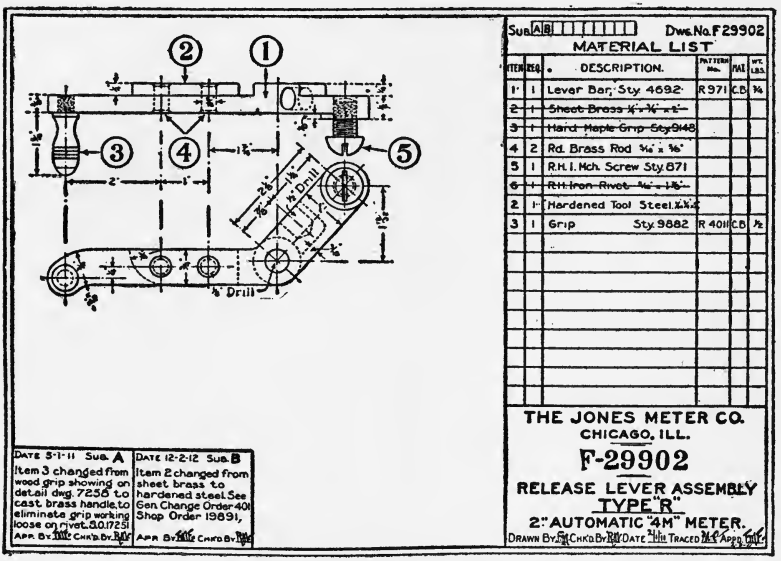


FIGURE II: Each item of material necessary to manufacture the article shown in the drawing is listed at the right. Numbers in circles corresponding to the numbers in the item column of the material list identify all parts, and clerical expense is avoided by making an extra print and cutting off the entire right end for the cost and stores department files

place to fit the order into the routine. Finally, he develops processing instructions for the close guidance of all those who will have anything to do with the work, from the superintendent down to the move-men. When the order goes into the shop, execution will then commence at once and proceed smoothly, quickly and without delays or mistakes, to completion on time and in the manner specified.

The greatest gain from following this procedure, of course, accrues to the factory which operates largely to customer's order. Then the necessity for specialized planning is greatest. But it is illogical to say of any factory that it can not afford a planning department. Planning must be done even if it does

not appear as a separate item, and economy indicates that it be specialized. In the plant manufacturing to stock, the procedure automatically reduces to an efficient routine. On manufacture to order, however, planning usually results in important economies. The expense, moreover, need never be excessive.

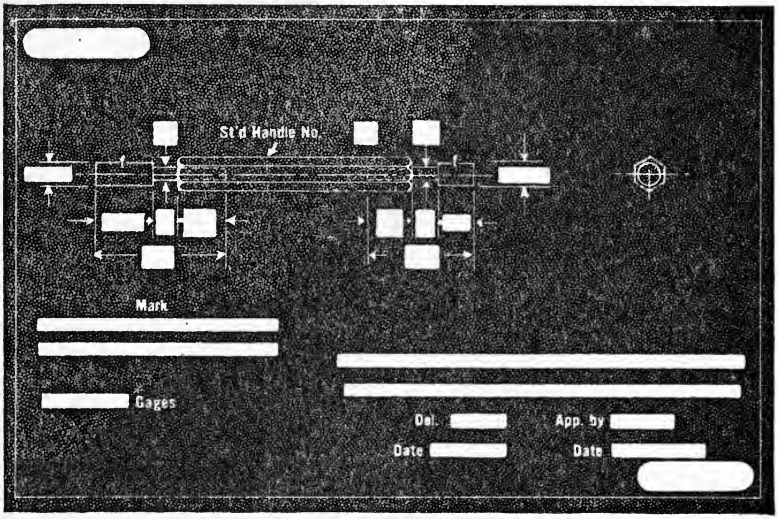


FIGURE III: By standardizing the styles of gages and small tools used in its plant, an Illinois company is able to have blueprints made up with blanks left for the dimensions. This method saves much unnecessary drafting on small jobs, and consequently helps to cut down the cost

New patterns and dies represent an expense which can often be reduced greatly by intelligent layout. An order is received for an article which differs in detail only from existing patterns. Rather than rummage through unsystematized files or tinker with drawings which may or may not fit, the draftsman prepares a new drawing, which necessitates new patterns or dies. Existing drawings or tools might have been used in many such cases, perhaps by altering some minor features or merely preparing sketches for the new elements. Particularly is this true in factories making an assembled, or built-up product.

In an engine and saw-mill machinery shop which prided itself upon the originality of its designs, this condition became so serious that specialists were called in to reorganize the methods of planning and laying out the work.

_____ Sheets Sheet No. _____ Written by _____ Proof-read by _____ Checked by _____	#2448 Miami #75 Connecting Rod. Drop Forging (1 per Machine). .25 point Open Hearth Steel.	Nov. 2, 1914 Dec. 14, 1914 Dec. 28, 1914	Time Allowance

Operations	Tools	Tool No.	Hours: Setting Up	Hours: Supervision	Wanted per Hour	Actual per Hour
1. Inspect forgings for imperfections. Reject imperfect castings and return to U. Mfg. Co. for credit.						
2. Clean forgings.						
3. Straighten if necessary.						
4. Stamp one side with cipher.						
5. (a) Drill; rough ream and finish ream in jig; place cipher side up.	Drill Press (1st Floor). Drill Jig. 1-3/64" Drill 1.047" Slip Bushing. 51/64" Drill .798" Slip Bushing. 1-1/16" Adj. Reamer 13/16 Adj. Reamer 1-1/16" Int. Plug Gauge. 13/16" Int. Plug Gauge.	210 stk 211 212 stk stk				
(b) Drill for #10-30 screw in end.	.161" Drill	stk				
6. Tap for #10-30 screw.	Tapping Machine #10-30 A.S.M.E. R.H. TAP. #10-30 Thread Gauge	 stk stk				
7. Burr holes.						
8. Assemble with #76 Bushing and #77 Bushing. Place cipher side up.	Arbor Press Assembling Fixture	 214				
9. Drill for (2) angular oil holes. Drill for oil hole in end.	Drill Press Jig. #22 (.157") Drill	 213				
10. Countersink (3) oil holes.	Speed Lathe Countersink.	 stk				
11. Spot for screw #78.	Speed Lathe #22 (.157") Drill Starter. 1/8" Drill	 stk				
12. Remove burr from bushing.						

Note: Have your work inspected every two hours. Inspect first piece finished on each operation before doing balance of the lot.

FORM VIII: In a factory organized on a scientific basis, thinking and planning are done by the engineering department instead of the workmen. The operator merely carries out the directions he receives from the production department. The above form is an example of carefully indicated instructions

Hart-Parr Co. Shop Order

Op. No.1 — A 94820 — Total No. Op.7 (2 3 4 5 6 7)

Order No. 995-9 Part No. 4142 Lot or Req. No. 349-Lot 83 Machine No. 87

Department Ordering SUPT'S Charge to Lot 83

Director E.L.J.

Date Ordered 6/13/14 What Purpose Used for Manufacturing

To Be Finished 7/5/14

Following are the departments through which this order must pass and who must sign up as order is passed along departments in order horizontally

Supts. Req. W.W.E.	Date 6/13/14	Instructor G.J.C.	Date 6/13/14	Estimator C.E.R.	Date 6/17/14
Supts. Req. P.M.	Date 6/17/14	Ar'g'm't Rack C.A.K.	Date 6/17/14	Check Room R.O.S.	Date 6/17/14
Stores A.P.W.	Date 6/23/14	Machine Shop	Date		Date
	Date		Date		Date
	Date		Date	Assembling Room	Date
Supts. Req.	Date	Cost-Time	Date		Date

Instructions

FLAT HEAD PISTON

Estimated Cost: .08

FACE END AND BORE FOR AUTOMATIC:

Insert 3" arbor through piston pin hole. Arbor should be long enough to project about 4" from each side of casting. Hoist casting on boring mill table with arbor resting on V blocks at each end. V blocks should be lined up so arbor is held exactly parallel with face of table. True up so end of casting can be bored exactly central with pin hole and strap V blocks down very firmly in this position. Also strap arbor down firmly in V blocks at each end. Chuck lower end of casting in jaws so sides are square with face of table on all sides. Face edge of casting true and square so it is cleaned up on all sides and rough and finish bore rim on inside to exact diameter given on drawing so it will engage centering plate on automatic properly. Place tool in head and bevel outside corner of casting so scale is cut from all sides at top of casting. Next operation is, BORE PISTON PIN HOLE.

Tools for This Order

Checked by W.B.

Over for Material, Time and Inspection Records

FORMS IX and X: Records of schedule, routing, instructions, tools, material, assembling, time and inspection are all provided for on one form, known as the shop order, in the plant of the Hart-Parr Company. The reverse side is shown on the opposite page. In the space at the top of the reverse

As an initial step, the consultants thoroughly overhauled the practice of the drafting room. They first standardized sheets to letter size—eight and one-half by eleven inches. This change made for convenience in handling and permitted vertical filing of both drawings and prints. Only one drawing was to appear on a sheet, and every separate piece for which separate drawings did not already exist was drafted again to meet this requirement. Some larger sheets were necessary for certain group and

Floor Inspector's Charge to Assembling Department									Assembling Dept. Returns		
No. Pieces	Date	By	No. Pieces	Date	By	No. Pieces	Date	By	No. Pieces	Date	By
Total Rec'd		Net on Hand in Assembly Dept.			Pieces by				Total Returned		

Time and Inspector's Records

Name of Workman	Time Started		Time Stopped		Total Elapsed Time		M'ch. No.	Op. No.	Inspector's Reports			
	Date	Time	Date	Time	Hrs.	Min.			Date	Amt. Given	Work Done	Signature of Inspector
H. Johnson	6/24	11 00	6/24	1130		30	#87	1	6-24	200	2/10	R. N.
	6/26	6 00	6/28	11 00	23	00	#87	1	6/26		16 3/10	M. H.
									6/27		18	M. H.
									6/28		8	M. H.
J. Wilson	6/25	7 00	6/28	6 00	40	00	#87	1	6/25		19 8/10	C. E.
									6/26		19 7/10	C. E.
									6/27		20	C. E.
									6/28		24	C. E.
Inspector's Totals												

Material Required

Quantity	Description	Weight Charged	Sig. and Date for Charge	Amount Returned	Sig. and Date for Ret.
200	Cast Iron Castings #4142	23800#	A. 6/23		
2	Scrapped 6/27/14 M. H.				
1	Scrapped 6/28/14 M. H.				

side an account is kept of the product sent to the assembling department. The easy comparison of one man's record with that of another encourages a profitable rivalry. This space is used only for the last operation orders. The form is a complete production record of one order

assembly drawings, but these were worked out in multiples of the standard size, so that they could be filed when folded. The drawings were consecutively numbered and when the design of any part was so altered as to require a new drawing, the revised detail was given a sub-number.

All drawings were indexed so that the engineer, knowing the subject, could locate any set of drawings at once. The rule was then laid down that before new drawings could be started,

a report from the filing department, approved by the chief engineer, must indicate that no existing drawing would serve. In this way, needless duplication was avoided. Additional sets of prints were grouped as the parts would be assembled and also for similar parts differing in details only.

Each print showed every essential dimension with allowance for machining or other shaping. To indicate the finish of the various surfaces, a system of symbols was devised, charted and posted around the factory for ready reference. This expedient saved time in drafting and reading prints and eliminated many errors that result from indistinct lettering or unusual wording. The drawing number, title, group to which a piece belongs, final article into which assembled and other indexing data appear on each sheet in a definite manner and place.

No separate sheet or card was provided for the details of the operation. These points, such as departments doing work on the part, operations designated by name and number, tools required, machine speeds and feeds, standard times for each operation and rates of payment with premium award if any, were grouped together neatly in the upper right-hand corner of the drawing itself. Only in rare cases was this space too small to carry the instructions. Thus the units for filing and reference were held to a minimum number.

Prints of parts repeatedly required were mounted on a light fiber board with a coat of shellac to preserve them, and were placed on file in the tool room. When an order reached the tool keeper he had only to consult the proper drawing in order to prepare the tools required. These he handed out together with the drawing itself for delivery to the first operation. The drawing traveled with the part until delivery to assembly, when it automatically returned to the storage as proof that assemblage had begun.

Hourly the tool-keeper reported the returns to the office, and by this information the control board record of manufacturing was kept posted. A duplicate of each drawing also was provided for the convenience of the tool man in assembling tools for succeeding operations. With the order he also received a copy of the production department schedule, by means of which to time himself in getting up the tools.

To aid the production clerks in laying out work and perfecting the detail schedule, "family-tree" drawings were provided by the engineering department for every assembly group. These showed the time required to produce each part, to make all sub-assemblies and the final erection. They were graphic charts to guide the production clerks in preparing schedules, issuing the instructions for the various operations, and keeping the control board up to date. Machine speeds and feeds, though arbitrarily fixed at the start, were soon corrected by time study and past performances to the point of thorough dependability.

THE THREE BASIC PRINCIPLES OF EFFICIENT OPERATION

WHAT was accomplished in standardizing and simplifying the work of layout at this plant points the way to savings which can still be made in most shops. Three simple principles are involved. The first of these is to have an approved way of accomplishing every operation. This way is to be established as the rule, usually by time and motion studies under a specialist on a basis of standardized equipment and working conditions. This data gives the production department the necessary known quantities in its problem.

To plan each step before attempting actual operation is the second principle. This covers the scheduling, layout and routing work done by the engineering and production departments on the basis of the capacity standards.

To reduce all standard operations to written form is the third principle. When dimensions, processes and order of operation have once been determined, it is logical to formulate them into a written or printed code for the future guidance of all concerned. Permanent drawings of product designs are probably the earliest examples of this principle. Yet the roughest pencil sketches of designs once served the purpose and such drawings still convey positive instruction on only a few of the points involved in manufacture. A thorough-going production order now indicates sequence of operations, definite procedure at every stage, tools to use, the time each task should take and the schedule of payment. With proper drawings as a guide, any factory can

build a fairly good machine or fashion an attractive piece of furniture, if given unlimited time and not curbed as to expense. Only the factory whose production clerk can indicate in detail the time, method and cost of each step, however, can hold its own against well-planned competition (Forms VIII-X).

With drawings, tools, dies and operations so standardized and indexed as to avoid all repetition of mental work once done, the factory can proceed at once with a layout of new points and thus secure a lead upon any old-style rival. This is the sound procedure in production layout. How extensive the operational instructions should be depends upon the character of the work. In the instance cited, the drawing itself carried the essential data. In some plants such directions as can be given on the time-cards are sufficient in many departments. On other operations, the work may be so complicated as to require a dozen or more typewritten sheets. The specification for assembling a traction engine or a saw-mill plant is voluminous and in preparation is a huge task, yet the success and economy of this plan has already been shown.

Permanent written standards in other cases are possible. In the works of the Westinghouse Electric & Manufacturing Company standards of practice on standard operations are filed at convenient points throughout the plant for quick reference by everyone concerned. Much made-to-order manufacture can be handled in this way. Such work is largely of a repetitive nature in which the same man may work on one operation for months or years. In such cases reference sets of specifications placed at the disposal of workmen, supervisors and time clerks serve their purpose. It is only essential to revise these instructions when operational changes are made, to advertise the change to the shop and to maintain the standard practice through the work of inspectors.

IV

WHAT QUANTITY TO MAKE AT ONCE

EVERY manufacturer, in putting through an order, encounters the problem of finding the most economical quantity to make at once. This is a general problem and admits of a general solution. Up to a certain point, mathematics answers it definitely, as with a thoroughly standardized product like automobile parts in a large plant. It is not put forth, however, that any mere mathematical formula can be depended upon entirely to determine how much stock should be carried or put through on an order. This is a matter that calls in each case for a trained judgment, for which there is no substitute. With special orders and under the emergencies that are constantly arising, the mathematical formula will, of course, give only approximate results, which must be tempered with judgment, based on knowledge of the factors involved in economical production and grasp of wise business policy.

Most managers are ambitious to emulate the big shop in its long runs. But the commodity on which a small business is based is usually of a different character from that which the big plant handles. Seasons and storage facilities vary. The demand for the article has its ups and downs. Special work constantly makes it necessary to recast the schedule. Equipment is limited or highly specialized, easy of adjustment or difficult and costly as to set-ups. Long runs are monotonous and often workmen lose interest. All these considerations and especially the requirements of the schedule and the expense of a new set-up are involved in every decision on size of lots.

Sometimes a day's run on a set-up is a sound limit. Such an

arrangement may make it possible to have the set-up handled out of hours. If only a few minutes is required to adjust the machine, and the adjustment can be made exactly without experiment, the length of run may make little difference in the cost. If the operator is working on a piece rate, one element in the cost of set-up is eliminated. But the question of idle machine time still enters. If the set-up is done at a piece rate also, the cost is fixed, whereas an adjustment at day wages is an uncertain quantity and requires strict supervision.

CALCULATING ECONOMICAL SIZE OF LOTS UNDER STANDARD CONDITIONS

IN CASES of minor importance a trained judgment based upon these points will determine the size of lots with sufficient accuracy. Where larger quantities are involved and conditions are standard, an estimate with its chances of mistakes should scarcely be final. Application of the mathematical formula is then warranted at least as a check upon the judgment. Given the size of lot which by mathematical theory is cheapest, the manager can the better supply such corrections as seem important.

In determining the economical size of lot the following main factors are involved:

Unit Cost (C). This is the cost in dollars per unit of output under continuous production, without considering the set-up or getting-ready expense, or the cost of carrying the stock after it is made.

Set-up Cost (S). This involves more than the cost of getting the materials and tools ready to start work on an order. It involves also, the cost of handling the order in the office and throughout the factory. This cost is often neglected in considering the question. Most managers, indeed, have a rather hazy idea as to just what this cost amounts to. If such is the case, an investigation will show that the cost of handling, checking, indexing and superintending an order in the offices and shops is a considerable item and may, in a large factory, exceed *one dollar* per order.

The set-up cost proper is generally understood. Indeed, shop

foremen appreciate only too well what the cost of set-up means on small orders, and so, if left to themselves, will almost invariably put their work through in large quantities to keep down this item. So doing, however, affects unfavorably the next factor;

Interest and Depreciation on Stock (I). Large orders in the shop mean large deliveries to the storeroom, and large deliveries mean carrying a large stock. Carrying a large stock means a lot of money tied up and a heavy depreciation. It will here be assumed that a charge of ten per cent on stock is a fair one to cover both interest and depreciation. It is probable that double this would be fairer in many instances.

Movement (M). It is evident that the greater the movement of the stock the larger may be the quantities manufactured on an order. This, then, is a *vital* factor.

Manufacturing Interval (T). This is the time required to make up and deliver to the storeroom an order, and, while it seldom is a vital factor, it is of value in the discussion.

There is another factor, X, the *unknown* size of order which will be most economical. Thus summarizing, there are the following factors in the problem:

M equals the number of units used per month (movement).

C equals the quantity cost of a unit in dollars or the *unit* cost.

S equals the set-up cost of an order in dollars.

T equals the manufacturing interval in months.

I equals the unit charge for interest and depreciation on stock.

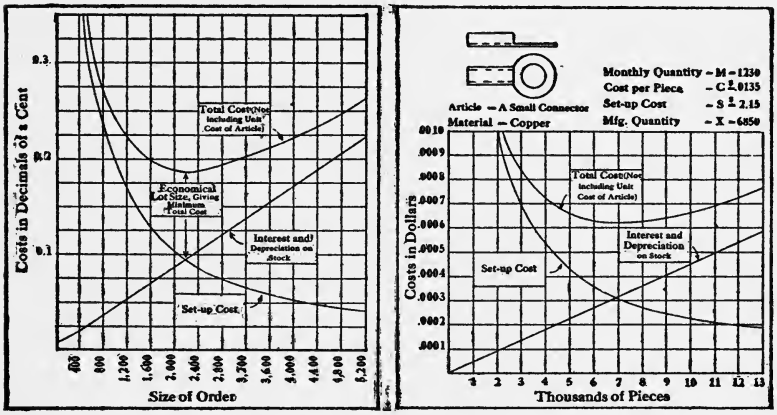
X equals the *unknown* size of order, or lot size, which is most economical.

The manufacturing interval is useful only in that it enables us to find the safe stock minimum, or smallest quantity the storekeeper may allow his stock to fall to before he must enter an order for more.

At first sight this minimum quantity would seem to influence the amount of stock and therefore the interest charges. It does nothing of the kind, however, and it will be found that the stock consists of additions in lots of X and a gradual exhaustion of the stock to nothing. The stock minimum simply serves to notify the storekeeper when to enter an order for new stock, so that he will use up his stock clean before deliveries on the new order

are made and, at the same time, never be without stock for any considerable interval.

The average stock, if the movement is regular, it will be evident, is one-half of X. If the movement is irregular, and it generally is, there is introduced an additional complication.



FIGURES IV and V: How costs vary in proportion to the quantity of product manufactured is illustrated by the graphs shown in these two figures. At the left, an increase in the size of the order results in an increased interest charge and a decreased set-up cost. The curves indicate a minimum total cost in this case of 2,200 units. At the right is shown the effect of the size of the lot on the set-up and interest charges per unit. The set-up cost curves slope downward with increased size of order while the interest curves slant upward. The sum of the two elements gives the total costs, the curve of which is the upper one and shows a minimum opposite where the two lower curves cross

This, however, can generally be neglected or applied as a correction factor to the final result. The average stock being $\frac{1}{2}X$, the value of this stock will evidently be C times this, or $\frac{1}{2}CX$ (value of average stock on hand).

This is the quantity cost only. To it must be added the set-up cost for the average stock. Since the set-up cost per order is S, and the average stock is half the size of an order, the set-up cost of the average stock will be $\frac{1}{2}S$. The total value of the average stock will then be $\frac{1}{2}(CX+S)$. The annual interest and depreciation cost at ten per cent will be one-tenth this or $\frac{1}{20}$ $(CX+S)$.

Now since M units per month are used, there will be 12M units per year, and this interest charge must be divided by the number of pieces used in a year to get the interest charge in dollars per unit, which gives $(CX+S) \div 240M$ equals I.

The total set-up cost for X units being S dollars, the set-up cost per unit must be S÷X. This now gives, as the whole cost of a unit, the interest charge per piece plus the set-up cost per piece plus the unit cost per piece, or

$$\frac{(CX+S)}{240\,M} + \frac{S}{X} + C.$$

Let this summation equal Y.

The problem then is the old one of finding the value for X that will give the minimum value to Y. As the solution of this problem involves higher mathematics, suffice it to say that the value for X that will give the minimum value to Y, reduces to the square root of (240 MS divided by C). Call this fraction V.

Now V may be calculated at once and the square root taken. Call this result K, because it will be a constant for any case. Then X equals K times the square of M.

HOW THE FORMULA FOR DETERMINING QUANTITIES WORKS OUT IN PRACTICE

LET an actual example be taken and see what the results will be. Suppose that an article has a movement, M, of 1,000 units per month with a set-up cost of two dollars and a unit cost of ten cents. Applying the formula, it is found that in theory the most economical size of lot is 2,190 units. This shows the set-up cost to be about 0.1 cent and the interest charges about the same amount.

In Figure IV, a curve will be seen representing the cost per piece of set-up for various manufacturing quantities and an interest and depreciation charge under the same conditions. The sum of these two is marked the total cost, although it does not include the unit cost of ten cents, which is not added because assumed constant.

It should be noted that this so-called total cost can vary between wide limits only when the manufacturing quantity is selected with very poor judgment. For example, in the case given, the least total cost possible will be about 0.188 cents at 2,190 units on an order. This quantity can vary from 1,000 to 5,000, and the additional cost will be only about 0.05 cent. On

an article costing ten cents, this is a very small percentage. While this is true for the values given it is not universally true, and thus it is seen that the general law can be applied with some profit to the specific problems of manufacture.

The theory underlying the economic size of lots, is not widely enough understood. For example, having once determined that it is wise to put in orders for lots of one hundred, based on a certain consumption, it is of value to know that this consumption must increase four-fold to warrant doubling the manufacturing quantities. It is further gratifying to know that the effect on profits from an error is as small as is shown by the curves.

This method is, of course, not rigorously accurate, for many minor factors have purposely been left out of the consideration. It may be objected that interest and depreciation should be figured, not only on original cost, but also on the set-up cost, since that has to be incurred before the parts can be stocked. Such points, however, while interesting, are too fine-spun to be practical. The general theory as developed here is reasonably correct and gives good results in determining one of the most perplexing problems of production.

V

REGULATING STOCK PRODUCTION

HOWEVER well production has been scheduled and laid out, there still remains the problem of seeing that the schedules are upheld and readjusted to new demands. Work must be traced and pushed. New work must be accommodated with the least possible disturbance to the fixed routine. Schedules will at times break down, and it then becomes the duty of the production chief to reestablish the even output of parts by speeding up one department, slowing down another, expanding certain facilities or giving the right of way to one set of orders over another. Capacity and requirements, changing hour by hour, must be reconciled to each other.

In dealing with these situations, railway operation offers a practical ideal toward which the factory may well work. No other business is perhaps so thoroughly scheduled as railroading. Through passenger trains have the right of way over local travel, and this in turn has precedence in general over freight traffic. The time table embodies these policies. Unforeseen interruptions, as flood, landslide and accident, break the schedule. Anticipated interruptions, as by special trains, also necessitate readjustment of the running time and the right of way. On a well-handled railway, however, the train despatcher always knows, for all practical purposes, where every train is. Whatever the interruption, accidental or designed, sooner or later the schedule again swings into force and every part of the equipment returns to the balanced condition of maximum use the traffic warrants.

So it is in the well-managed factory. Getting varied ship-

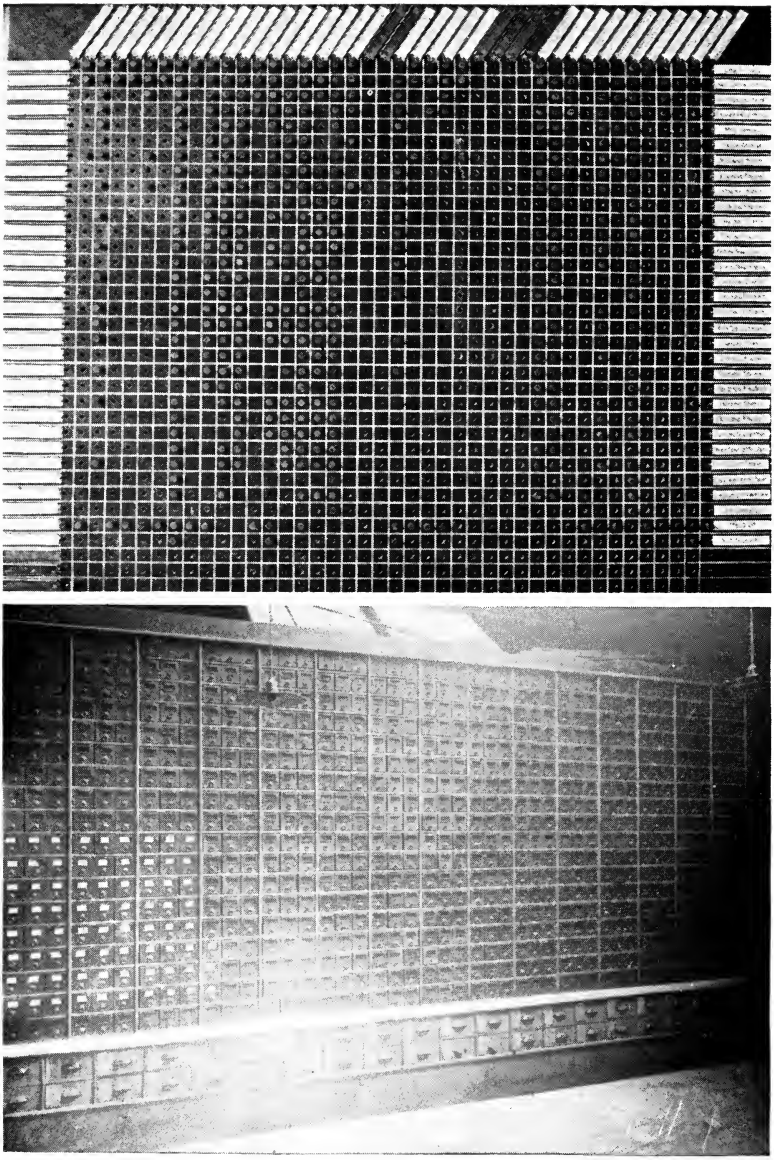
ments out on time, tracing work and fitting special orders into the routine, are, after all, only problems in routing—or assigning the track; scheduling—or fixing times; and despatching—or issuing instructions to proceed. Through the orders issued from his office and the reports he receives on train movements, the train despatcher holds his traffic under control. When control is lost, disaster is likely to follow. In the factory, likewise, through orders issued to foremen and workmen, in connection with reports received from them, the manager controls, rearranges and expedites work. Cost and output are right or wrong, other conditions being equal, as this control is close or loose, strong or weak.

Just as "train sheets" is a despatcher's office help to control the movements of trains, so similar methods—some of them simple and graphic and others filling intricate record sheets,—are central in importance to the control of manufacturing in many plants. By their means the production clerk has before him constantly the place of every order in the routine. Some of the parts needed for assemblage of product may lag behind the rest; he gets in touch with the tardy department and, by means of extra forces or overtime work if necessary, brings it up to schedule. When new work comes in, it is evident in the same way what departments are on schedule and where a new order will best "sandwich in."

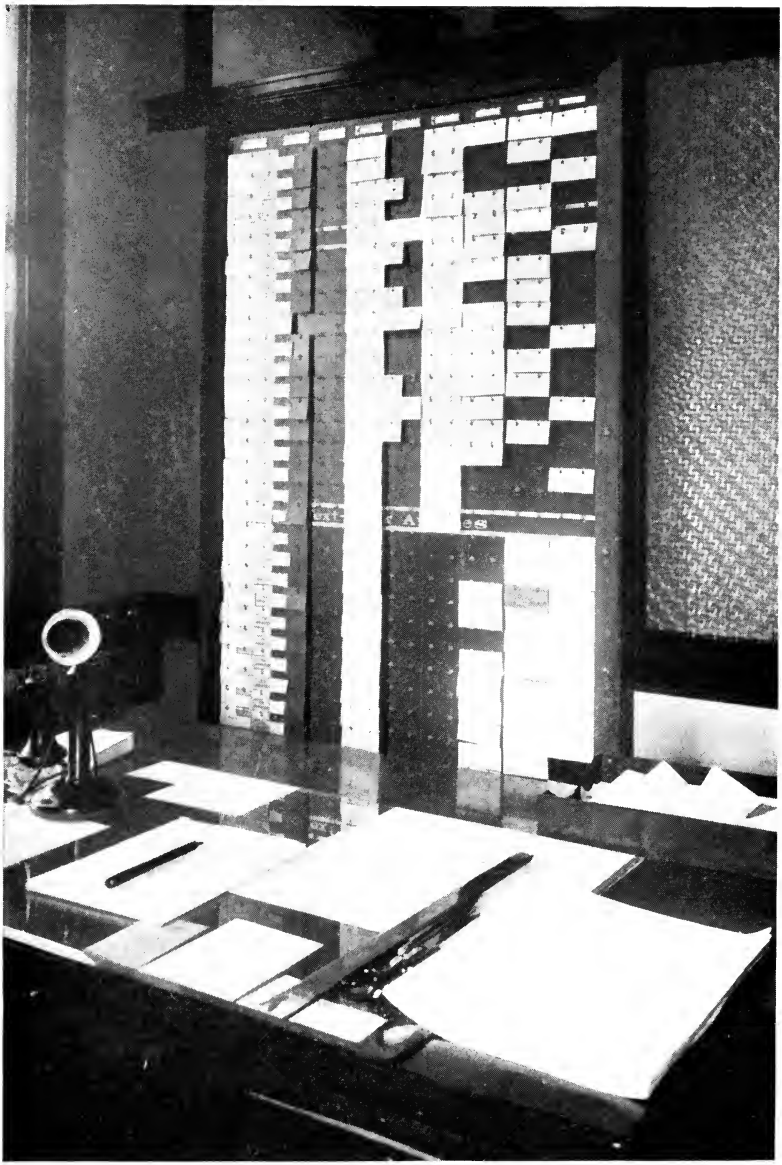
SIMPLE GRAPHIC SYSTEMS FOR FACTORIES MAKING TO STOCK

FACTORY work, from the production clerk's viewpoint, of course divides into two principal classifications, stock and special or job orders. How the former are handled is the first and the basic problem.

Stability is one of the requisites to efficient production. The steadier the flow of work the year round, in the smooth channel of uninterrupted routine, the more effective is the working force and the lower the cost to make. To insure this condition in the face of a variable demand from consumers can be done in only one way—by making to stock. The result is the same as from storing up water in a reservoir—it equalizes the flow of work



In a metal-working plant, operations are listed down the side of a production record board (above), and headings for jobs are placed across the top. Plain and colored pegs indicate the progress of the work. At the Dodge Manufacturing plant a box rack contains the tracing cards (on all district orders), to be attached to all castings as soon as they are ready to leave the foundry



On this planning board the assignment and routine of work is scheduled for months ahead. Different colored tags aid the eye in recognizing at a glance the stage any task has reached. Lapping tags upon one another economizes space, and "cut-outs" permit notations on under tags to be read without removing the upper one

and provides a steady load on the organization in spite of fluctuations in the stream of orders. Not only does it permit large-lot production, but it also is indispensable to perfectly scheduled operation. The most efficient factories are thus able to conform more closely to these two virtually interdependent principles—working to stock and working to schedule. Standardized operation and uniform costs otherwise can only be approximated.

In recognition of these principles, many "order" factories have been striving to get on a stock basis. There are still people in most communities who can recall when every farmer brought his own corn to the mill for meal, but now the entire equipment of many new plants is based on a uniform demand carefully investigated before manufacture begins. Even such concerns as the Link-Belt Company, which class primarily as job or engineering shops, are stock propositions up to the point of assembling. While making to stock offers the manufacturer exceptional opportunities for economy, however, unless production is carefully planned and adjusted, with finished stock storage to meet trade demands, neither the expected economy nor reasonable satisfaction of promised shipping dates will result.

So it is customary in plants making to stock, for the production and sales departments, if possible, to schedule the work at least six months ahead and to adhere closely to this program. Under this arrangement the problem of keeping production in balance and investment busy is at its simplest. An inventory record of finished parts and completed assemblies suffices to keep the production clerk informed on the progress of the work.

The factory assembles a definite number of the product each day and the rate at which parts are made is fixed solely by economical size of lots. The frequency of orders for any part is governed automatically by the minimum limits prescribed on its inventory card. Apply such a plan to one highly specialized product, such as the Ford or Franklin automobile, and you have perhaps the ideal manufacturing proposition.

At the Franklin plant, the entire production is controlled by a series of graphic stock boards (Page 73). By moving a graduated tape over a series of blocks which represent stages in the production of each lot of parts, a perpetual inventory of goods

in process is furnished. Orders to produce, materials, new drawings and tools—all are controlled by these boards, which once set remain fixed for the six months the schedule runs. So reliable is this record that photographs of it are accepted by the auditors as an actual inventory of parts in process.

Weekly Production 100 Date Jan. 4, 1915

Production Schedule

Total Order 2000 Name Hickory Gas Range

No. per Stove	NAME OF PART	Jan. 10	17	24	31	Feb. 7	14	21	28	March 7	14	21	28	April 4	11	18	25	May 2	9	16	23	30	
3	Angle Iron Bands																						
2	Angle Iron Splice																						
1	Asbestos Holder																						
1	Body																						
1	Body, Lower																						
2	Body, Sides																						
1	Body, Back																						
1	Body, Top																						
1	Body, Base Strip																						
2	Body, Lining Support																						
1	Body, Collars																						

FORM XI: To keep supply three weeks ahead of demand is the aim of the stove company using the graphic record here shown. By it shortages are avoided and overstocking prevented. The weekly quota is entered at the top. Once a week this record, which is kept in a loose-leaf binder, is brought up to date by tracing the horizontal lines for each part. The condition of stock on any order is at once apparent

Such graphic methods of control have a strong appeal, particularly to the man in the shop. To him records that require the frequent use of the pencil, or the deciphering of someone else's handwriting, are in general distasteful. Moreover, they waste his time. Even clerically trained men evince a strong preference for graphic records. As a stock record clerk once said: "It is more like play to operate them."

At the Hart-Parr plant is found another excellent example of graphic control of stock production. In the finished-parts storage, a bead rack (Frontispiece) enables the man in charge to keep close and accurate tab on the production of parts and their delivery from the machine shop or raw material storage. Accordingly, when he receives orders from the main office to issue parts to the assembling department to apply on a certain lot order,

he can see at a glance just what he has on hand and how many, if any, complete sets of parts he can issue for assembling.

Farm tractors are manufactured in this plant, in lots of twenty-five or multiples up to one hundred. It is of course the endeavor, by means of a planning board operated in the machine shop, to have all the parts that apply on an order number made up and delivered to the erection stores simultaneously in so far as is practicable.

As the parts are delivered the storekeeper moves over, on the line opposite the part number on the rack, beads to correspond. There are in all four racks, one for each type of tractor produced. Parts delivered are identified by lot number and this is marked with chalk on a small bit of blackboard projecting above the rack like a flag.

At the top of the rack is a scale graduated in one hundred parts. The unit of graduation is the width of a bead. A pointer slides along this scale and from it is suspended a plumb line. This is moved to keep pace with the delivery of the part or parts most backward. Every tenth bead is white in color and of slightly larger diameter than the darker colored intervening counters. This facilitates the operation of the rack.

Thus at a glance it is plainly evident how many tractors in any lot can be erected at once, provided it is desired to begin erecting in advance of the completed delivery of the lot. If more than this number of tractors is wanted, the storekeeper can start tracers after the laggard parts.

By this means one man in the shop is enabled not only to control simply and practically the operation of the final department, but also to apply the pressure necessary on preceding departments to keep production in balance.

Entries of parts as received are also made on a five-by-eight card form, but this is for the information of the office and is returned to it as the notice of completion of the order and giving the final information necessary to close the office production record.

This scheme of graphic control has a wide application in industries that make to stock. It is scarcely practicable where the line is large, and where a great number of different kinds of products are coming through at the same time, for too many

racks would be necessary. But where, as in this instance, the line is highly specialized and the variation in pieces is chiefly in size, making possible practically a uniform classification of parts, it is difficult to conceive of a simpler and more efficacious means of control.

In a number of factories similar stock records are operated on large blackboards. At the Cincinnati Shaper Company, for example, production is controlled from six large blackboards, arranged in two groups of three each separated by a wall column, each board moving in an independent set of grooves like a window sash and the three when spread out encompassing the entire story height. In another instance, similar boards are swung like the leaves in a book from an interior column, and in a third the boards are arranged to slide horizontally and when not in use are nested in a large cabinet against the wall. The latter plans are preferable to the first in that both sides of the blackboards are available for records, although the first arrangement has the merit of being more graphic.

Any scheme based on the use of blackboards or bead racks, however, is defective in that the record may easily be tampered with and no permanent record of each change in the quantities is provided. For inventory purposes, therefore, a separate paper record must in any event be maintained. The only apparent alternative, as at the Franklin plant, is to photograph the board or rack every time the figures are changed and so closely to supervise it between times as to insure against irregular changes.

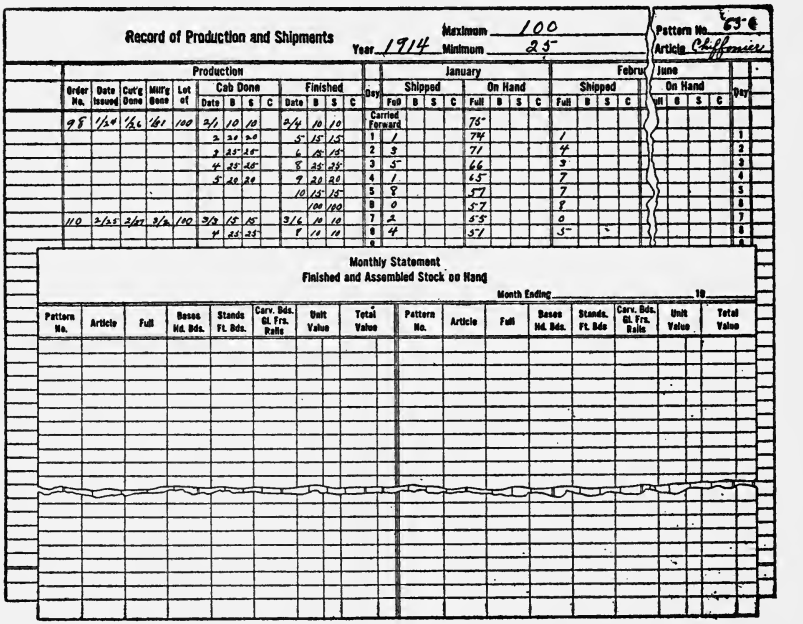
LOOSE-LEAF PRODUCTION RECORDS THAT HOLD DEPARTMENTS TO SCHEDULE

IN MANY plants the requirements of schedule control are more difficult. Permanent records are required. Many varieties of goods may be manufactured. It may be impossible to keep to schedule at all times, but is necessary to have the system flexible enough to allow for rush and special orders. Such are the conditions at the plant of Rathbone, Sard & Company.

Stoves are the output of this company—both cast-iron for coal and sheet-metal for gas and oil—and in each line the number of styles is large. The typical stove has, moreover, upwards of a

hundred parts. As the problem of keeping production in balance of course grows in perplexity as the number of articles increases and is at its worst when orders call frequently for departures from standard, it is evident that to control this supply of parts is not a simple matter.

Practically all the manufacturing is to stock and the aim is to keep the supply three weeks ahead of demand. So the problem resolves itself into controlling the shortages and avoiding any considerable overstock.



FORMS XII and XIII: In controlling the output of a plant employing one hundred men, an eastern furniture company uses the statement shown in the lower form. It is made up quickly from an inventory record such as that described in this chapter. Another furniture company controls output largely by the use of the form at the back, which is a record of production and shipments. These sheets are easily kept in a spring-back binder at the manager's desk

At first the management attempted to handle the matter by means of open board charts. On account of the number of these required, however, the scheme was shortly abandoned and a loose-leaf record substituted, in which the principle of graphic presentation still appears. One of these production sheets (Form

XI) is made out for each style of stove or range upon which production is started. At the top is entered the weekly quota which the capacity of the plant will permit. The date the order is started is entered at the right. The total order divided by the stipulated weekly production gives the number of weeks over which the lot will be coming through. The vertical columns are then dated in accordance.

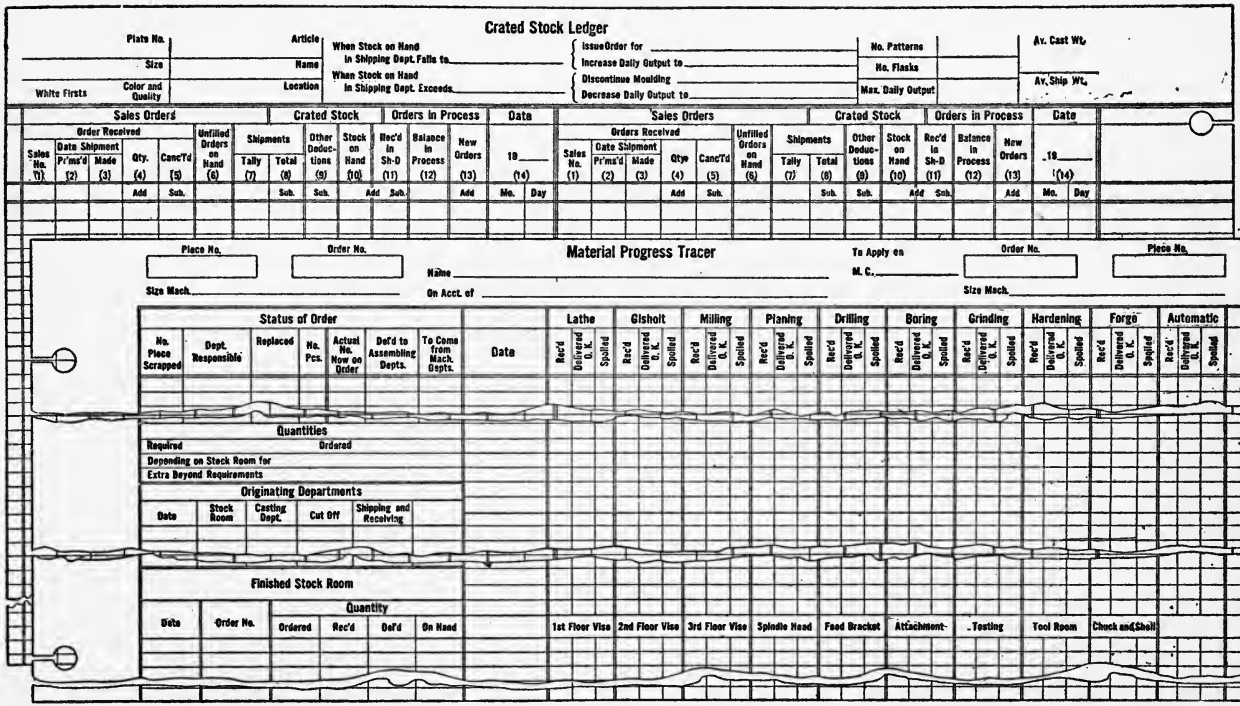
At the left columns are provided for the names of the various parts and for number of each required to a stove. The horizontal lining is correct for single typewriter spacing, so that the names may be typed in if convenient. The order of parts is the same as on the master production order, which facilitates reference from one to the other.

Assembling is not started until the three weeks' supply of parts has been accumulated, and from that time on is at the same rate as production, unless an unusually large order is placed for that particular stove. In this case the daily quantity to be assembled is temporarily increased.

The records are kept in loose-leaf binders and are in charge of the production clerk. Once a week he goes through each schedule and brings it up to date.

Instead of entering any figures or check marks he traces a heavy horizontal line for each part. Thus he, or anyone consulting the record, can see at a glance the condition of stock on any manufacturing order. The production clerk's chief concern, of course, is shortages, and as soon as any line falls short of three weeks ahead, special attention is given to this item.

A list of parts behind schedule, known as the "short-call," is made up, the period short in each case being stated. The production clerk, with this list, then refers to the master production orders to see whether or not manufacturing is in process on the short parts. If the record shows that these have been started, he next consults what is called a "labor efficiency" record, by which he learns how far along the manufacture is. He makes the proper notes on the "short-call" and then gives it to the foreman of the initial department. At the same time production orders are issued for starting parts not already in process and from day to day these shortages are followed up and urged through. The production clerk, if need be, goes into the factory



FORMS XIV and XV: Some record of material in process is nearly always necessary. The lower form furnishes a complete history of the progress of parts in a machine-tool plant, while the upper form yields a similar service for an ironware manufacturer. The latter ships almost entirely from stock. When stock runs low the relation between sales orders received each day, stock on hand and orders in process indicates the proper move

in person and follows the parts upon which delivery is most backward.

By this means one man can easily keep the entire production in fair balance.

The task would be easier were it not for the number of special orders received. A salesman from one territory writes in and wants this feature altered to enable him to land a promising order; another writes in and wants some other feature changed, perhaps on the same stove. Then the part or parts to be replaced must be laid aside and substitutes, of the required special design, rushed through. Inevitably the result is a continual upsetting of the balance. Immediately there is an oversupply of the part changed and an emergency shortage of the new piece.

These difficulties, of course, the chart cannot handle. A special follow-up must become responsible for the completion of the new pieces, as indicated in the next chapter, and a record of the oversupply sent to the production clerk, so that he can subtract it from the quota of that part when he places his next stock order. But the schedule is a great help, and has been the means, through better control, of considerably increasing output and reducing costs. More important still has been the better satisfaction given the trade. Failure to ship on time is the cardinal sin in distributing a product. Under this plan, the office closely controls production, and promises to salesmen are based on exact knowledge.

Almost identically the same control plan is employed by the Thomas B. Jeffery Company. An additional feature of interest is the carrying of the balances right on the chart, so that no reference to inventory cards is necessary.

HOW A PRODUCTION RECORD GAVE A MANAGER A NEW GRIP ON HIS FACTORY

BROKEN promises and failures to meet orders promptly almost wrecked one plant which was not shipping on time. Popular priced cabinet and bedroom furniture is the output of this factory. As the business had grown, the manager, trying to get along with as little "red tape" as possible, had found it increasingly difficult to control his production. Manufacture was almost entirely to stock and the slight variations were unim-

portant. But this or that pattern would suddenly run out, and, pending the execution of a rush order, shipments had to be held up. Every now and then a good customer would lose patience at this delay and withdraw his patronage.

So large, moreover, had the number of rush orders for stock designs become that the shop was disorganized. Hardly an order for manufacture to stock pursued its way uninterrupted. Eventually production would be completed on the majority of these, but always the side-tracking of an order meant a congestion of the floor space, which further handicapped operations. All too frequently, parts thus side-tracked would fail to resume their journey. When these pieces were needed for assembling, on hasty search they often would not be found. In this case, the recourse as usual was a rush order. So it went on from bad to worse, and in proportion as the confusion increased, profits dwindled in spite of mounting sales.

Finally the management consulted a production expert. He immediately saw that the business had grown too large for one man effectively to control it without the aid of records, no matter how familiar with the details or how able he might be.

So he set about devising a simple production scheme, by means of which the executive could regain his grip on the factory. Several forms were required, including a new manufacturing order, an identification ticket to accompany work through the mill, individual time notes for the men, and departmental delivery records to check the forwarding of parts from one department to the next. The pivotal form, however, was a record of production and shipments (Form XII).

This sheet is ten by seventeen-and-a-quarter inches, ruled and identical on both sides, with the exception of the topmost column headings. These, on the one side, are from January to June, and on the other, from July to December. There is, of course, a sheet for each pattern manufactured and these are kept in a spring-back binder, classified according to articles. For instance, all the chiffoniers are together, and all the buffets.

The first five columns explain themselves. The next four columns, under the secondary heading, "Cabinet Work Done," are provided, the first for the date and the other three for the quantities finished, bases (B), standards (S) and caps (C) being

listed separately—as the cabinet work and also the finishing is performed separately on these three sections, which only finally come together in the shipping room. If there is but one section to the final piece, only the first column is used.

Four similar columns follow under the secondary heading, "Finished." Quantities here listed are available for immediate shipment if necessary, but ordinarily go into stock.

The next single column contains the days of the month, numbered from one to thirty-one, and fixes the position, according to date, of all quantities posted to the right of it.

Then follow, under the names of the months, six groups of columns of eight divisions each. These in turn are arranged in two groups of four divisions each—one for the listing of pieces shipped, the other for the record of balance on hand. The first column in each secondary group is for the record of "full" pieces shipped or on hand. The remaining columns are for the separate accounting of bases, standards and caps.

This record affords a perpetual inventory of the entire production. A glance shows not only the balance on hand of finished stock but the quantity, if any, in course of production at each important stage. Maximum and minimum limits are set and when the balance on hand reaches a minimum, if sales orders are continuing to come in at the regular rate, a new manufacturing order is issued.

At the end of the month, by adding the quantities in the "Shipped" column, the total shipments for that month are obtained. This total must agree with the shipping room records. By subtracting this total from the balance on hand at the beginning of the month (plus pieces delivered to finished stock that month, if any) the balance on hand to carry forward is obtained. This should agree with the final figure in the current balance-on-hand column.

TAKING CARE OF PRODUCTION IN THE FACE OF HEAVY SEASONAL DEMAND

AT THE foundation of every successful stock manufacturing proposition is some kind of an inventory record of goods finished and in stock, available upon requisition of the sales

department. This in its simplest form may be identical with the form used for controlling the balance on hand of raw materials, supplies, accessories and manufactured parts. And it need never be more complicated if the quantity of finished goods were always equal to demands. Most lines, however, are seasonable, that is, during part of the year production at the average rate greatly exceeds the demand, while for a short period—perhaps two or three months twice a year, goods are shipped out so rapidly that the balance on hand soon vanishes and shipments have to be promised on the strength of goods coming through. It is, moreover, desirable so to determine the maximum stock limit as to bring about this condition. Less money is then tied up in finished stock on the average, smaller storage capacity is required, and a wholesome stimulus is imparted to the entire factory organization when the crest of the demand is reached. To be able intelligently to promise goods not yet completed, as well as closely to adjust the orders-to-produce with the peak-demand, it is in any event practically necessary to operate an inventory record which comprehends the entire situation, from orders started to goods stocked or shipped, showing at every stage the quantity of the product in process.

Such a form is shown in Form XIV. It is an eleven by fourteen sheet, identical on both sides except for the order of information at the top, which is reversed on the rear, and is filed in a loose-leaf ledger. As each page is arranged for two rows of entries, one sheet is equal to a single record four times its depth, and serves for a long period.

At the left is a series of columns for the inventory of sales orders: (1) the sales number, (2) the date shipment is promised, (3) the date actually shipped, (4) the quantity ordered, (5) cancellations, if any, (6) the unfilled orders on hand, which is the balance forward plus column (4), minus columns (5) and (8). Then follow the columns for the inventory of stock, (7 and 8), the shipments, (9) any other deductions from finished stock (to make good defective ware returned or when a piece becomes damaged after going into stock), (10) the stock on hand, arrived at by subtracting (8 and 9) from the balance forward, after the fresh stock delivered from the packing department has been added from (7). Finally are the columns for the Orders-in-

Process. The balance forward (12) minus the goods reported into stock plus the new orders started the same day give the number of orders in course of production. At the extreme right is a date column which applies to all the rest, except the dates of shipment. Column (11) is common to the Orders-in-Process and the Finished-Stock Sections, and (7 and 8) to the Finished Stock and Sales Orders. These columns might have been repeated to make each inventory section complete, but clerical labor is saved and a more compact form secured by the arrangement shown. Sections might also have been included for the balance in other departments and these would have their value for inventory purposes, but inasmuch as the interval between orders issued to the originating department and delivery to stock is fairly constant, the record of orders in process suffices as a basis upon which to promise shipments when the crated stock runs low.

At the top of the sheet are various blocks for the complete identification of the article inventoried below, and also for the maximum and minimum stock limits upon which the orders to manufacture are based. Both limits have two alternatives. When the stock on hand sinks below the minimum, a lot order may be issued for a specified quantity, or if it is a tonnage article, that is produced so many each day, the daily quota is increased. On the other extreme, manufacture is either discontinued until further notice or the daily output is decreased. The maximum possible daily output is another fact recorded and in connection with it the pattern and flask equipment for that particular article. Thus if it becomes necessary to produce more than the present capacity affords, the number of new flasks and patterns required is apparent at a glance. The average casting weight and average shipping weight are two other recorded facts which have their value when a statement of tonnage produced by the foundry or shipped out has to be made up in a hurry. The plate number is placed in the upper right-hand corner (upper left on rear), and the sheets are so filed, dispensing with a separate page number which would require a cross index.

This form, specially devised to fit conditions in an enameled ironware plant, would serve with detail changes in any factory making a non-assembled product. Even in a parts factory, it

would do for the final assembling operations; but additional records on the same order would be necessary for each part produced and each sub-assembly, unless, of course, orders for all the parts necessary to make a certain quantity of assembled product are issued simultaneously and assembly is not started until these parts are delivered. Then the entire record can be operated on one sheet, as in the case of the furniture manufacturer.

VI

SPECIAL AND MAINTENANCE ORDER SYSTEMS

SPECIAL order propositions differ radically in several respects from manufacture to stock. From the latter, the variables of execution can almost entirely be eliminated. This, in fact, has been pointed out as the main compelling force toward stock manufacture. Not so the purely special order proposition. Here the variables predominate. Each order brings up new problems. The experience of today may afford little or no guide for the work of tomorrow.

Before the shop can be started on a special job, extensive and expensive preliminary work may be necessary. Some designing and drawing are always to be done, even though the customer furnishes fairly detailed plans and specifications. Some new patterns and tools, too, usually are required and in the extreme case, an entirely new outfit. Facilities frequently prove inadequate and additional equipment has to be provided. The required materials seldom are on hand and some of these may be totally strange to the purchasing department; hence, the buyer must be given time to search the markets and obtain quotations and deliveries. Considerable experimental work may further be necessary to determine the proper materials or to check the design or for both purposes.

In spite of all these indeterminates, however, the cost must be estimated and the date of delivery promised. If under such conditions the factory comes out ahead on a given order and does not lose all it might otherwise make in penalties for tardy delivery, it may consider itself fortunate.

An extreme case of special order manufacture has, of course,

been stated. The majority of special order shops have standardized their efforts considerably. They confine themselves to working in one material, as leather, wood, iron, or brass, or to certain general types of product, as electrical machinery, material-handling equipment or made-to-order clothing. Again, there is specialization within each of these branches. For example, one firm may limit itself to sheet-metal products, another to crucible-steel castings, a third to machine-shop work. By narrowing their efforts in this way, job shops in time accumulate a wealth of experience in their special lines which enables them to eliminate many of the variables and closely control the rest. New orders are gaged by comparison with former ones, which differ only in size or minor details. Indeed, many special order factories today are special only as to certain details of their product. Moreover, these factories whose lines at no point admit of making to stock are more and more centering their sales efforts on getting a class of work that suits their facilities, and when special jobs requiring extensive special preparation are accepted, it is with the understanding that neither the price nor the date of completion will be guaranteed.

SPECIAL ORDERS IN EVERY FACTORY—FOURTEEN PRINCIPLES THAT APPLY

ON the other hand, not even the purely stock factory is wholly without the special order problem. In its maintenance and betterment work, if nowhere else, this class of order is always present. Then, too, practically every stock factory has a certain amount of customers' repairs, and few occupy so commanding a position that they are not obliged occasionally to vary their standard product in some degree to suit the special requirements of a customer whose valued and important patronage might otherwise go elsewhere.

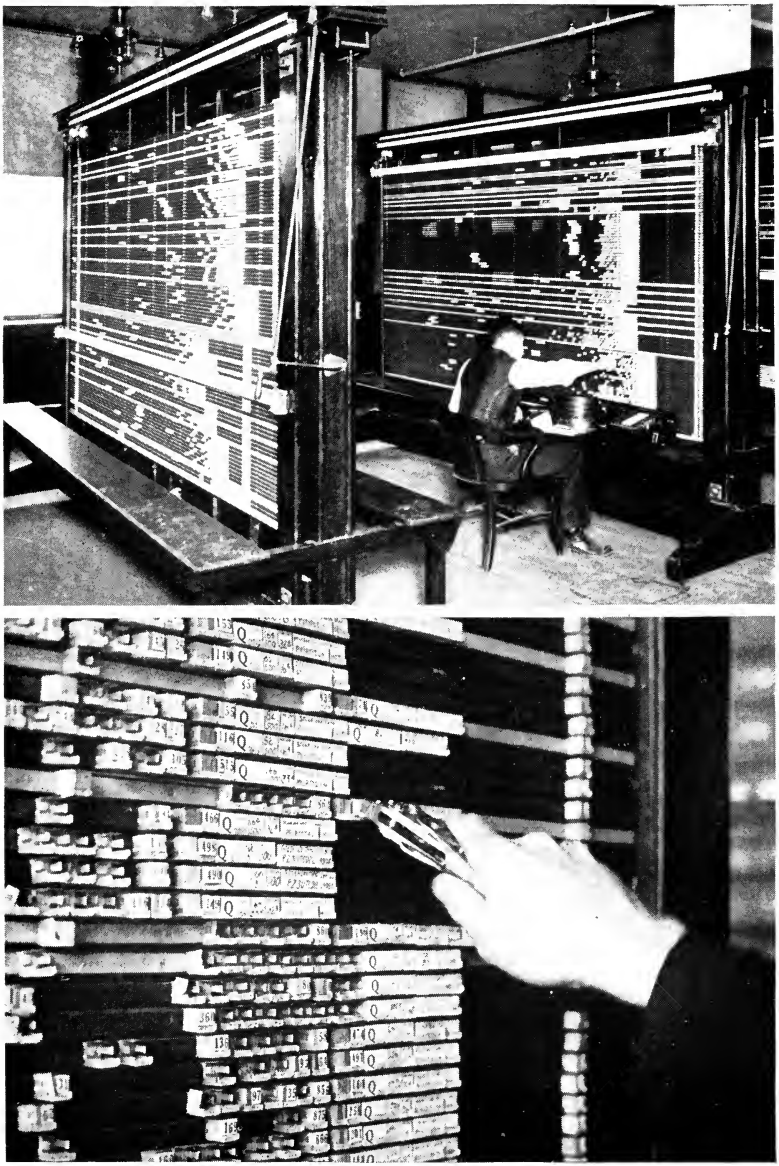
So, then, methods of handling special work have a very general interest. These may be stated as the principles governing the execution of this class of orders:

1. Analyze each order into its constituents.
2. See what drawings and patterns on hand will serve as they are.

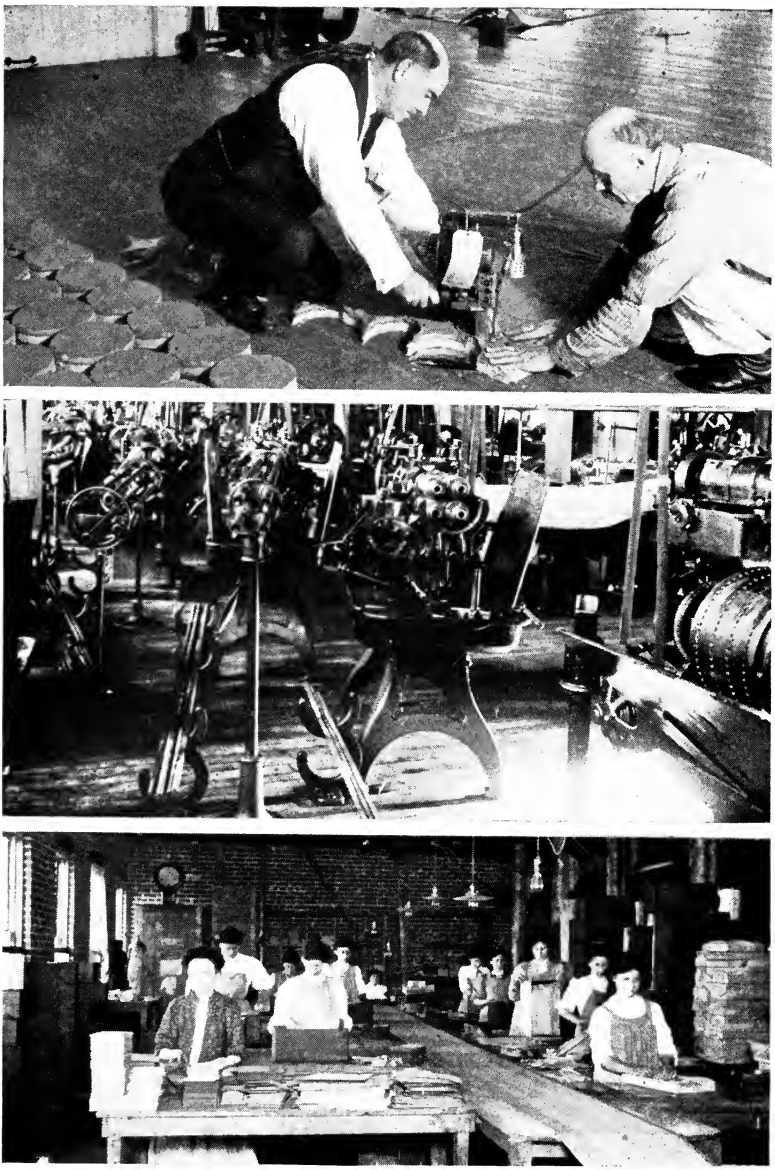
3. See what drawings and patterns on hand will serve with minor changes.
4. Find out what special tools will be necessary.
5. Find out what new or additional materials it will be necessary to purchase, and place orders therefor.
6. Estimate the cost and time of each operation required, where definite standards are not possible.
7. Time orders to shop in accordance with dates when new drawings, tools, equipment and materials will be ready.
8. Schedule and route each order as its importance and the state of orders already in the shop indicate.
9. Operate a close follow-up from the office to insure that this schedule is being observed strictly.
10. Sidetrack orders in process for the benefit of special rush orders only on the highest authority, and at the same time see that orders sidetracked are scheduled anew.
11. Separate stock from special manufacture. If essentially a stock factory, yet required to fill many special orders, set aside a portion of each department for the latter.
12. Promise delivery conservatively, and if you see you can't make it, advise customer promptly.
13. Keep an accurate record of the time and cost on each order and compare with preliminary estimates.
14. Grade foremen and men on their ability to keep within the estimates.

These principles cannot be applied without reserve in every case, nor where applicable in general will they fit certain peculiar details of the work involved in getting out special orders. Designing, which is mostly creative effort, for instance, cannot be scheduled definitely nor the cost absolutely predetermined. However, even in this case, it is often well to place a time and cost estimate on each job, if for no other reason than to impress upon the minds of the designers that these items count. Also, when limits are prescribed, thought is stimulated and many times a higher grade of intellectual effort secured. If such work is not scheduled, a promise at least should be obtained from each man and a close follow-up operated on the promises.

So the need for system, in a special order factory, begins in the drafting room, as the definite planning of an order cannot be done until the engineering work is completed. The system need not be complicated—the main essentials are that the executive know definitely the whereabouts of each order and its status at all times, and that a tentative schedule at least be



Manufacturing to stock is regulated automatically by highly organized control boards at the Franklin Automobile Company's plant. Each horizontal half-inch represents a working day. Block symbols (below) and a movable tape (left, above), schedule every operation. The boards are photographed for permanent records, and the prints are accepted as inventory statements of work in process



Typical production short cuts are here shown. In making silk bags (above), to contain smokeless powder for the guns of the United States Navy, bottoms and caps are cut out in quantity by an electric blade. Stock for the job in process and for the job next ahead is held in semi-circular racks (middle). A belt-conveyor determines the rate of production in the packing department below

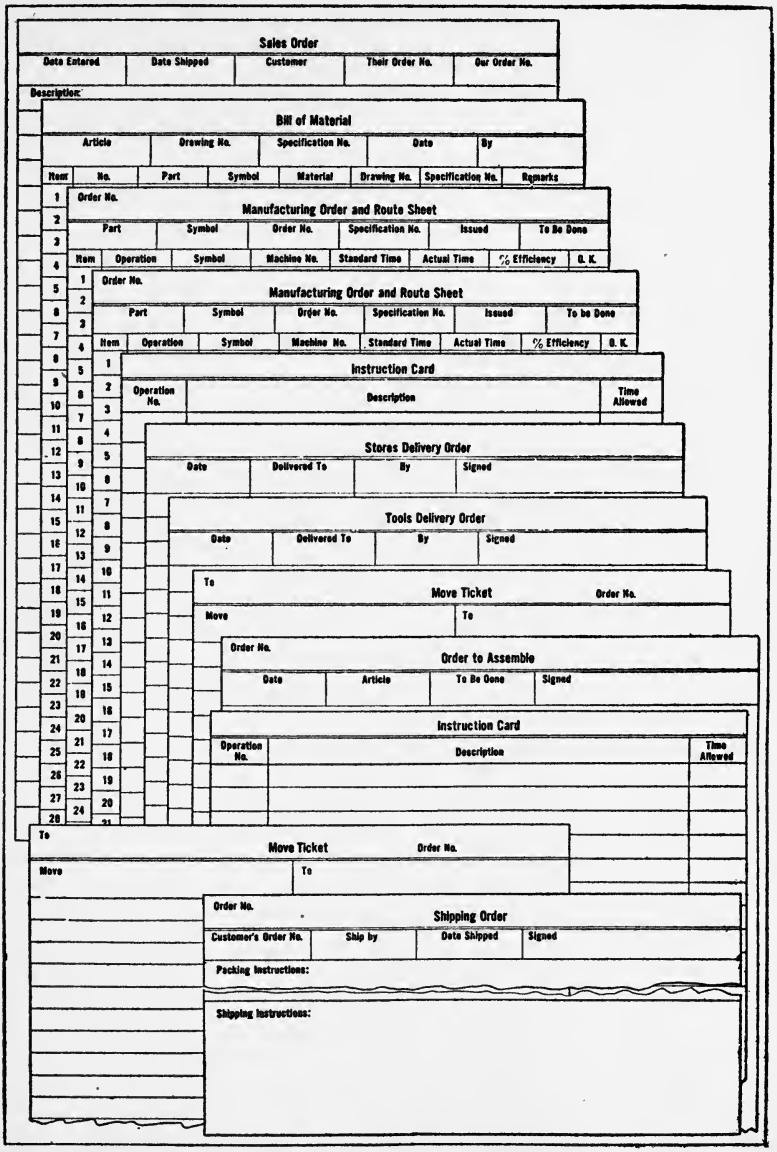
observed. If some graphic means of control can be devised, so much the better.

A particularly good example of this kind of control is in use by the Norton Grinding Company. A detailed report is required every day on all the orders in process in the engineering department. Near the chief engineer's desk is a large peg-board (Page 55), which is a graphic reproduction of the report sheet. It is divided like cross-section paper, and in the center of each square is a peg hole. At the left and right extremes are tabs for the listing of the various operations on an order, while across the top are other tabs—one above each vertical row of squares—for the designation of the orders. The tabs are little metal frames into which are slid slips of paper. The board is divided into sections according to the several kinds of engineering work handled—original design, special design, general design and otherwise.

Once each day a department clerk goes to the various division heads in the engineering department, who have different jobs under their supervision, and learns from each engineer what work has been done since the last report. Returning to the board, the clerk inserts pegs in accordance. Thus the board shows at all times the status of every job in the department within twenty-four hours and it can be worked as much closer as is desired. The heads of the pegs are large enough so that the date of each operation can be marked on them and where orders run for two months or longer, different colored tops are employed to distinguish the months at a glance. Another interesting plan board carries colored cardboard disks which flag the unfinished work—the danger points—and are cleared away as manufacture proceeds. These schemes are not limited to control of engineering work, but may be extended to include all the operations in a factory and in almost any kind of business.

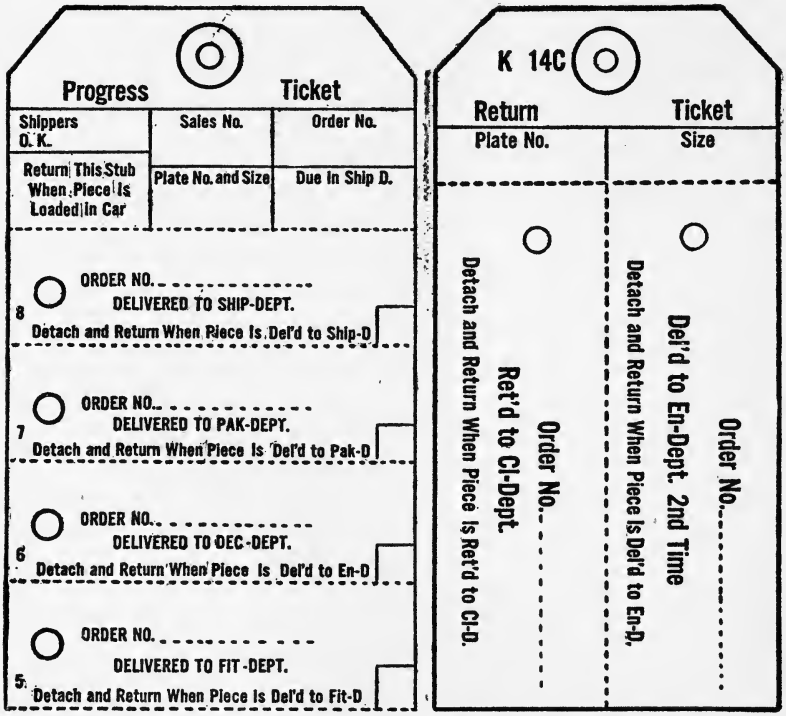
FOLLOWING SPECIAL WORK BY CONTROL BOARD AND ORDER COUPONS

STILL another type of board which has a broad application is in use in the same ironware plant referred to in the preceding chapter, and was devised to give better control over orders for



FORMS XVI-XXVII: Special orders require many more forms than stock orders. All of the essential forms for carrying on production under special orders are here shown. Stock orders require only the manufacturing and assembly orders, stores and tool delivery tickets and the shipping order. Bills of material, drawings and specifications are on file. In case production is steady, procedure is still simpler, as only standing orders to make are necessary

specially drilled or finished fixtures. This control board is double faced, painted black and supported on a revolving stand, so that it may be swung around to face in any direction. Like the other board mentioned, it is divided into rectangular spaces and a small brass hook occupies the center of each space. The



FORMS XXVIII and XXIX: To route and trace the movement of pieces on a special order is the function of the tag at the left, which accompanies each piece throughout the chain of operations. The various coupons are detached in turn and sent to the office, where they are placed on a progress board, by which the manager can tell within an hour or two the exact status of each piece on the special order. The tag at the right is used for imperfect pieces in the same plant

steps in the progress of any order are listed at the left—not the operations, but the points of transfer from one department to another are indicated. Headings across the top are unnecessary, as the first coupon of the routing tag (Form XXVIII), issued with each order and hung on the top hook, carries the complete identification.

This tag is made up of coupons, one for each stage in the execution of an order. It is prepared at the same time the production order is made and is sent with the first copy of that order to the originating department. The bottom coupon—"Order Issued"—is detached when the tag goes out and hung on the top hook. As many tags are issued as there are pieces on an order and all the coupons are hung from the same hook.

When molding is started, the foundry production clerk detaches the second coupon—"Started" and places it in a coupon box in the department office. Here it is found by the mail boy

Production Record Order No. _____

Article	For Whom					Molding	Casting	Cleaning	Grinding	Planing	Milling	Boring	Drilling					
Our Order No.	Their Order No.																	
Date Entered	Promised	Assembly Started	Finished															
Part		Purchase Outside	In Stock	Production Order		M	C	Cl	Gr	Pl	Mi	B	Dr					
No.	Name			Date	No.													

FORM XXX: Provision for checking every operation is made in the production record here shown in part. The original is extended further to the right, and each step in manufacture is given a column. The exact stage of any order is indicated by the presence or absence of check marks in the various columns

on his next round and delivered to the progress-board clerk in the office, who time-stamps it and hangs it on the proper hook.

So as the pieces on an order progress from department to department, the successive coupons are detached, reach the office, are time-stamped and hung on the board. If for any reason a piece is thrown out in process, the whole of the tag remaining is sent in and then the production clerk considers whether or not to issue a new order to make up the loss. If all the coupons do not come in promptly and a loss is not reported in the manner described, the production clerk either gets after the delinquent department by telephone or goes personally into the factory. He

knows when the various coupons should come in by consulting daily his follow-up file of production orders, on which each stage of the work has been scheduled. When a piece is delayed because, after reaching the enamelling stage, it is found to need more grinding, filing or sandblasting, or has been incorrectly drilled, the fact is reported by a red coupon (Form XXIX), which the inspector who orders the return attaches. A second red coupon is returned when the piece goes forward. When the pieces reach the shipping department and are loaded into the cars, the tag stubs with the clips that attached them to the ware, are returned and the hooks are then cleared.

Before the institution of this method of handling special orders, the sales department were continually on the heels of the factory manager with complaints about the tardy progress of special orders and he had no way of satisfying them except by telephoning various department foremen or going out personally to investigate. The sales manager or one of his assistants, too, frequently spent an hour or two a day tracing orders in which he was particularly interested. Now the manager merely glances up from his desk at the progress board and the sales force walk up a flight of steps instead of going on a long journey through the factory. Even this is unnecessary, as failure to meet shipping dates is now the exception rather than the rule.

PUSHING MAINTENANCE ORDERS AND ASCERTAINING THEIR COST

MAINTENANCE and betterment orders in the same plant were also put on a correspondingly systematic basis. For these, a special service order form was first devised. This is provided in five colors, a different one for each of the five service departments—pattern shop, carpenter shop, machine shop, construction and repair department, and drafting department, with a white copy for the office follow-up. Spaces are provided on the order for the date of completion and the estimated time and estimated labor and material costs, with parallel columns for the actual quantities. Every order must be estimated as to time and cost and a date of completion stated, whether data from previous similar work is available or not. In the absence of data, the order

clerk must see the various foremen concerned and secure estimates from them, before he can issue the order. Progress is checked by placing the office copy of each order in a follow-up file. On the date completion is specified, a foreman must either return the order signed as finished or on the back of it give his reasons for needing further time. His copy is returned with a new due date stated, after the proper notations have been made on the office copy.

At the same time the service order is made out, a cost sheet is prepared (Form XXXI). The upper part of this sheet is identical with the order, permitting the use of a carbon. Monthly the labor and material charges reported against a service order number are transferred in one item to the cost sheet and when the order is returned as completed, the record is closed and it is the work of only a few minutes to calculate the cost. This total is then entered on the appraisal or charged to the proper expense account, depending on whether it is a betterment or maintenance order, and the sheet is transferred to a finished order file. A marked improvement in the control of service work, as well as a steady reduction in cost, resulted from the installation of this system.

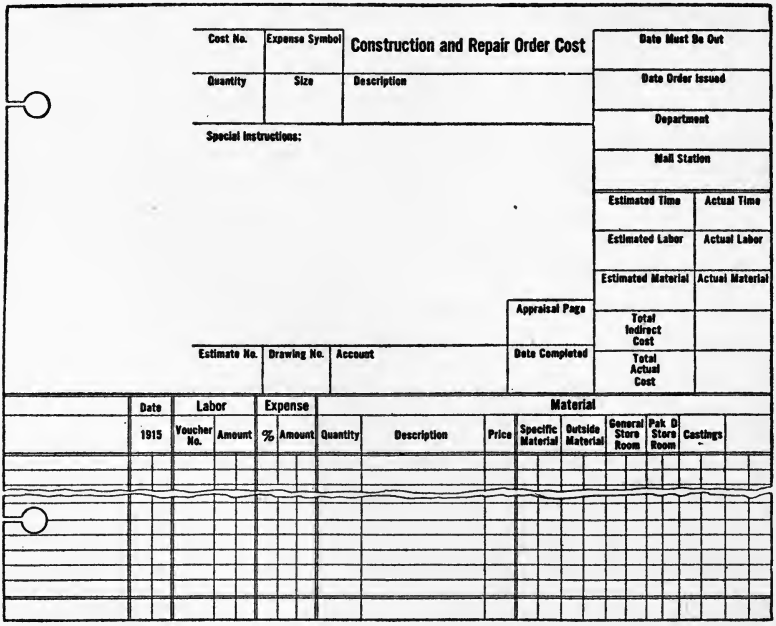
Almost identically the same scheme is in operation in a job brass and German silver mill, for handling and getting the cost of each order from the point in production beyond which every job is special. This is from the scratching room on. Up to this point, the mill operates on a stock basis. Bars from the casting shop are put through several stages of rolling, whereby they are lengthened several times and reduced in thickness. Then before further reduction, the surface must be cleaned, or "scratched." Thus it is convenient at this point to stock the bars.

The upper portion of the order cost blank is a carbon duplicate of the shop order on which stock is issued from the scratching room. Each order is further identified by a mill-order tag (Form XXXII), the lower part of which is detached and returned to the office when the material is issued. This coupon carries a duplicate of the information on the upper part of the tag and is the follow-up. In the blocks shown, the various com-

pletion dates are entered from the workmen's time tickets. On return of the rest of the tag, the two parts are clipped together and placed in a completed job file.

MAINTAINING THE SCHEDULE ON SPECIAL ORDERS FOR BUILT-UP PRODUCTS

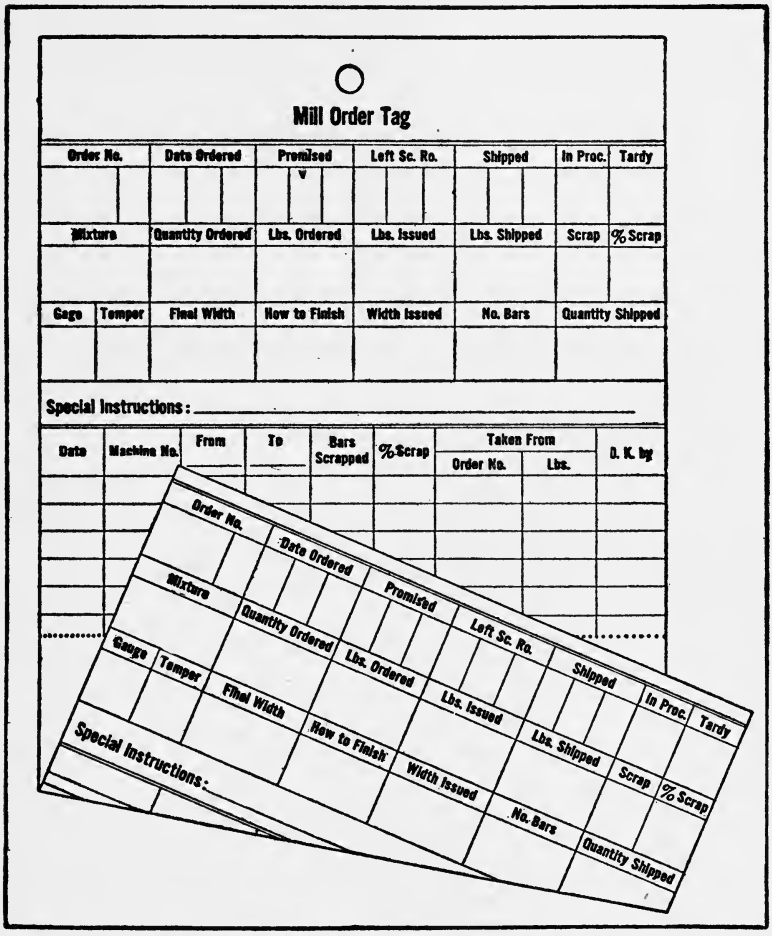
SPECIAL orders on built-up articles present a more difficult problem, and the difficulty increases at least in proportion to the number of parts. This is because a separate follow-up must be operated on each part and simultaneous delivery effected on all the parts entering into an assemblage. The problem in



FORM XXXI: By having the upper part of this construction and repair order cost sheet identical with the order form itself, both can be made out at the same time. Note the provision for the estimated time and cost, for comparison with the actual. By carrying out this feature scrupulously, the production clerk maintains his control over dates and costs

the majority of cases is of course simplified by the fact that many of the parts will be carried in stock or purchased outside. Graphic schemes of control are less useful under these conditions, although a chart on the same general plan as the produc-

tion plan board mentioned on Page 75 would apply to many such orders. It would serve, for example, when all the parts went through practically the same operations. Omitted operations,



Mill Order Tag

Order No.	Date Ordered	Promised	Left Sc. Ro.	Shipped	In Proc.	Tardy

Mixture	Quantity Ordered	Lbs. Ordered	Lbs. Issued	Lbs. Shipped	Scrap	% Scrap

Gage	Temper	Final Width	How to Finish	Width Issued	No. Bars	Quantity Shipped

Special Instructions: _____

Date	Machine No.	From	To	Bars Scrapped	% Scrap	Taken From		O. K. by
						Order No.	Lbs.	

Order No. | Date Ordered | Promised | Left Sc. Ro. | Shipped | In Proc. | Tardy

Mixture | Quantity Ordered | Lbs. Ordered | Lbs. Issued | Lbs. Shipped | Scrap | % Scrap

Gage | Temper | Final Width | How to Finish | Width Issued | No. Bars | Quantity Shipped

Special Instructions: _____

FORM XXXII: This form, designed for a copper-alloy mill, serves as an order and a routing tag from the cleaned bar stock-room. The lower part is detached when the stock is issued, and returned to the office, where it serves as the follow-up. As reports are received on the progress of the order, the information is entered in the blocks below. When the order is shipped, the top is returned, the statistical data is posted and the entire record is filed

too, could be indicated by a different colored disk. The chief defect is, of course, that no record is maintained of the dates the

various operations are completed. A scheme based on the use of cards and date signals, therefore, is more generally acceptable.

In one plant cards are made out for all parts and filed in sequence in a tray. Across the top are the days of the month. Parts in stock are indicated by one color of signal, those purchased by another color. The latter cards are set according to the dates the material will be available. Similarly other colored tabs are placed on the cards for parts to be made on the premises, and are moved forward as reports are received indicating the progress of the work. These are broader tabs of white celluloid and the proportion or number completed is written on in pencil. Thus the production clerk, merely by glancing through his file of cards, can tell the status of all the parts, time his orders to assemble in accordance with his reports, and if production is lagging on any parts, send out tracers. The proportional rule across the top of the cards, in combination with signals, is another follow-up device for both stock and special orders.

Still another variation is in use in a New England factory. Cards are made out for all parts, just as above. The various operations, however, are listed vertically along the top edge and the signal is moved forward from operation to operation as these are reported done.

Sheet records are also in use in a number of plants. All the parts comprising an assembly are listed (Form XXX) at the left. The first column to the right is headed "Purchased Outside;" the second, "In Stock;" the third, "Date Order Issued;" and fourth, "Order Number." Heading the various columns following are the operations in sequence. In using this chart, the first step after ascertaining what parts must be made, is to go through and for each part, to cross out the irrelevant operations. Lines are also drawn across the page opposite the items in stock or to be purchased, to make parts to be manufactured stand out more prominently. When purchases arrive, a circle or other suitable symbol is drawn around the check mark in the first column. As operations are reported done, the dates are entered in the proper spaces. The job time tickets furnish this notification. Thus the production clerk, by faithfully oper-

ating this record, can watch production closely, follow lagging parts and bring his orders to assemblage on accurate schedule.

HOW TO ORGANIZE FOR PERSONAL FOLLOW-UP ON RUSH JOBS

IN an Indianapolis saw factory where each foreman still acts as his own production clerk, a "hurry department" is maintained which well illustrates the principles of personal follow-up and accurate records so important in connection with special orders. The plant suggests a method of fitting "rush" orders into routine, which is adaptable to almost any business.

One tactful and energetic man and an assistant constitute what might be called the "production department" for special orders. To the head comes every order and letter—from traveling salesman, branch house or customer—suggesting need of dispatch. Acknowledgment is not made immediately by the order department; the sale is simply recorded, numbered and copied in manifold for the shop orders, then turned over to the hurry desk.

If the case is urgent, the head or his clerk takes the order directly to the foreman who must get out the work (Form XXXIII), and they agree on a shipping date. As soon as a satisfactory promise and schedule are secured, the hurry desk makes out a "rush slip" (Form XXXIV) for its tickler file, checking the date of receipt and the date of shipment promised, the branch house or district in which the order originated, the factory number and the department having the work in hand.

The original letter and order are then turned over to one of the order correspondents—the hurry desk is in the same room—with the information secured and perhaps a suggestion as to framing the acknowledgment. If delay is unavoidable because of factory conditions, the head or his assistant dictates the letter and makes it clear to the customer why his demands cannot be met.

In the hurry department's "tickler," the rush slip (Form XXXIV) is filed far enough ahead of the shipping date to provide for a successful eleventh-hour effort to finish the job on time. For instance, if the foreman has been given three days

to get out some simple device which could be rushed in a single day, the hurry slip is filed for the day of shipment. If the order is for a more elaborate appliance promised in eight or ten days and requiring half that time to machine and assemble, the hurry slip is filed for the date when work must be begun and on that date, after the shop has received its nudge, is re-filed for the day before shipment.

If an appliance must be passed from department to department, its progress on the appointed days is traced as if shipment were involved. Where two or three or ten factory numbers are to be included in one customer's shipment, the factory order for

Entered 8/16 — Hurry Slip — Minor Mill Co.

Check Date of Re-promise	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Branch Sending Order

Atlanta Chicago Memphis Minneapolis New Orleans New York Portland San Francisco Seattle Toronto

Order Number	Circular Inst.	Circular Large	Circular Small	Shgl. Hdg.	Drag Gang	Hand	Butch. Kitch.	Miscl.	Wood	Band	X Cut	Cyl.
35890	6	40" Slashers										

The Original Promise on the Order Was for 8/21

Delayed (State Cause) In Toothing—Must go 8/19

RUSH

See That This Order Is Attached to Your No. 35890

For Prompt Shipment

Give Promise and Return This Slip to Hurry Department

Circular Dept. 8/16

FORMS XXXIII and XXXIV: Holding a department foreman to his promise has been made easier in one factory by the two forms here shown. The "hurry" order card, which is inked in red, is given to the department foreman by the order clerk if the job is to be rushed. Form XXXIV (at the right) is the "rush" slip for the tickler file indexed by shipment dates

each notes that they are to be shipped with the other numbers on the date fixed and a separate "rush slip" is made out for each in the hurry department tickler file. Each morning, of course, the tickler shows what jobs must be investigated and started towards definite conclusion. If for any reason an extension of time must be made—non-delivery of raw materials or of castings from the foundry as an example—the tickler cards are changed, the new date of promise checked, the first date noted in a space reserved and the cause of the delay made clear. Promptly, too, the customer is notified in a letter of explanation

and apology written by the hurry head. If more than one appliance is involved, a partial shipment is promised, and made on the date originally set for shipment. The branch house, too, is informed of the delay.

On the copy of the factory order given the foreman, the form is stamped, "Hurried.....," "Promised.....," and the date is filled in. On the material process ticket which accompanies the job in its progress through the shop the foreman indicates the dates on which each machine operation must be performed and stamps the ticket "special hurry," "express" or "urgent," as the situation demands. The original order is kept in his tickler file and handled much as is the "rush slip" in the hurry department. In the more highly organized plant, all these functions would, of course, gravitate to the production department, to which the plan outlined might easily be adapted.

It is the duty of the shop tracer to see that each job is kept to schedule and to call the attention of the foreman to any lagging order. The tracer system if rigidly carried out, would make the hurry department unnecessary. But systems and foremen sometimes break down under stress unless a check is maintained on them. This check the hurry department affords. If a foreman refuses to better a shipping date which strikes the hurry man as unfair to the customer, the matter is referred immediately to the superintendent, who takes up the matter with the foreman and makes the decision. If the foreman fails to make good his promises, the superintendent again is informed. His intervention, however, usually is invoked only when overcrowding of a department demands some change in its shop practice.

One further check on the progress of urgent orders is afforded by the shipping department, which receives a copy of each factory order. Those stamped "Hurried-Promised" are filed by dates, apart from the regular orders.

In the application of any method for pushing through special work, the importance of maintaining the general schedule should prevail. If charged with the disarrangement of the general schedule which the special order involves, the latter will be found so expensive that it will be tolerated only in cases where the

factory is especially organized for it and where prices accurately match the true costs. To maintain the steady stream of standard production to which every department contributes its utmost is the true aim of the chief production clerk as he dispatches the work and watches the schedule hour by hour.

VII

KEEPING QUALITY UP TO STANDARD

QUALITY is the final aim of production. Quality in the factory, however, means not necessarily the highest grade, but *fit* grade. In every well-governed plant, the quality of the product has been defined closely by the aid of laboratory tests and micrometer gages; it is the concrete expression of the factory's reason for being—a definition of the value which the management has determined to give at a certain price, in order to meet competition and make a place for itself in certain veins of trade.

If the business is to be successful, the quality of the product and the character of the service rendered in connection with it must in the main compare favorably with what consumers can obtain elsewhere at the same price. With every fluctuation from the determined quality, therefore, the position which the business holds is in danger. Too high quality means sales at a loss; too low, lost sales.

Once quality depended entirely upon the skill and integrity of the foreman and his men. Under standardized production the chief responsibility has in many cases been shifted from the craftsman to the trained inspector. Through both plans, however, the central principle persists; set up accurately determined standards for materials and work, governed by what the trade demands and what the factory can do; as often as necessary, compare the goods in process with these exact standards, under conditions that assure trained and unbiased judgment.

Eternal inspection, in other words, is the price of quality

production. It is not enough to know that the raw material entering into the product stands all tests, or that the product when completed serves temporarily with apparent fitness. Between these extremes of production, comparison of standard and output must be made in a multitude of details, if the good reputation of the brand is to be upheld. This need for inspection of details is particularly important in the manufacture of machines in which the subdivision of labor makes each man responsible for the production of a single wheel or lever, any one of which, turned out as they are by thousands, may be defective. The inspector's eye must detect these spoiled pieces before they slip further down the line of production, for the greater distance a defective part has traveled from its originating department, the more expensive is its replacement.

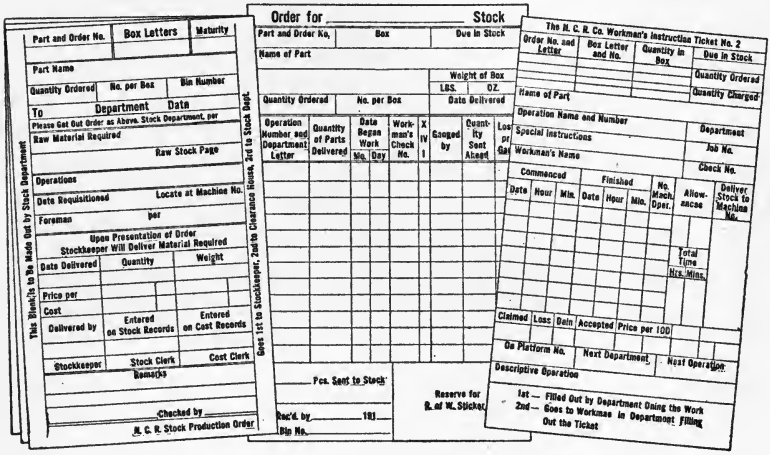
HOW QUALITY IS MAINTAINED AT THE NATIONAL CASH REGISTER PLANT

THIS work of keeping quality up to the mark by careful and systematic inspection in step with production has been worked out minutely at the plant of the National Cash Register Company. Everywhere the principle of sound inspection is evident. Standards are absolutely fixed, in whatever refinement is practical. And to insure accurate comparison, inspectors and superinspectors are supplied who are trained, rendered independent of production authority, to free them from bias, and organized like a system of courts and judges to avoid the miscarriage of quality in any case. Not only is inspection of single and assembled parts carried on with great accuracy, but the work of the inspectors themselves is checked in turn. Between every two departments stand inspectors, making it almost impossible for a defective part to escape detection and enter the next process. Imperfect work is quarantined at its point of origin, which is the first law of inspection.

After the testing of the raw materials, general or parts inspection, assembling inspection and final inspection are the three steps in keeping quality up to standard at the lowest final cost. It follows that what you pay for inspection service increases in direct proportion as the number of parts and the complexity

of the assembling process increase. Aside from cost considerations, however, all three steps are possible and necessary with all but the simplest articles, if quality is to be raised to a high level and kept there.

This three-fold, inter-checking inspection service is thoroughly established in the Dayton plant. A detailed study of it will

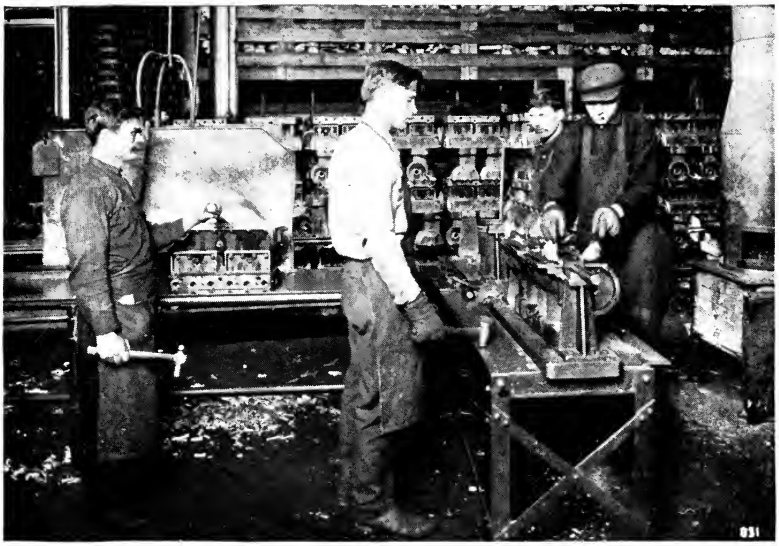


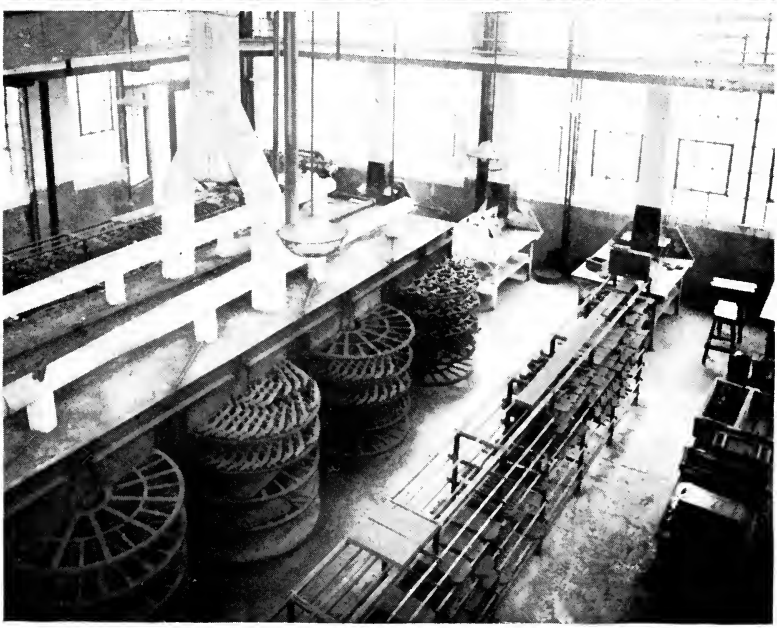
FORMS XXXV-XXXVII: At the left, Form XXXV shows how material is ordered into the factory by the stock department. Form XXXVI (center) accompanies the stock on its journey from the clearance house to the processing departments. These journeys are routed by the moving ticket, at the right. The duplicate moving ticket is slipped into the box-pocket along with Form XXXVI. The purpose of all of this procedure is to insure high-grade quality all along the line of manufacture

reveal methods that can be adapted to other lines of manufacture and on a smaller scale with equally good results.

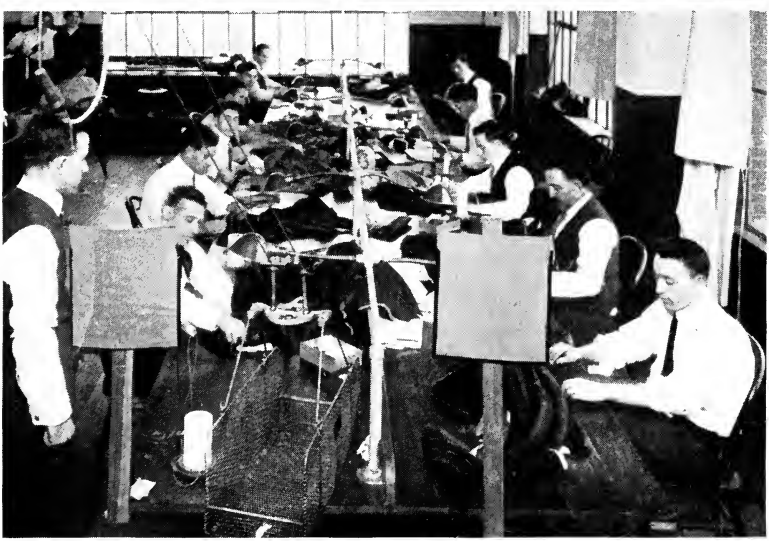
The general inspection department, as already indicated, criticises the work on finished parts in every processing department. The machine units are then inspected as assembled. And finally, a corps of experts pass on the mechanical accuracy and finish of machines, and in so doing also check the work of the general inspectors.

Handling the two hundred million pieces of stock which yearly pass inspection at the National Cash Register plant is the first operation in the inspection system which has been outlined. Scores of men and thousands of gages are used. Many of the parts cannot vary more than 0.0005 of an inch from the exact size, and in no case is a variation of 0.002 inches allowed. So





Both product and operation in the Ford plant find the shortest road to completion and then stick to it. Through the babbitting process (above), castings move steadily in "Indian file." Each man has a definite station and task. In the foundry (below), cores are loaded on the exposed half of the turnstile, while cores on the other half are baking



In the factory of the Kahn Tailoring Company baskets run by trolley from the central control station to the work tables, where different parts of a suit are made. Each day's allotment of work has a separate set of compartments in the semi-circular rack above. Colored signals at each table indicate what day's work is in progress. The aim is to get tomorrow's flag up before the whistle blows today

accurate is this inspection of parts, that practically no fitting has to be done in the assembling room.

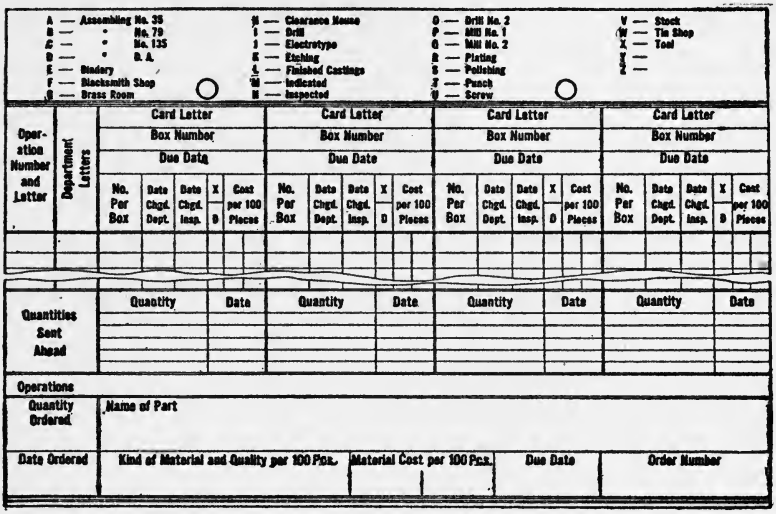
A rather novel department, known as the clearance house, acts as a go-between in handling the work in the manufacturing processes. As its name signifies, this department has to do with transfers of orders and stock. The stock, when delivered from the storeroom as raw material, is sent first to the proper machine room, in suitable boxes. The manufacturing process is subdivided into departments, each in charge of a foreman. There are foremen of milling, bench work, filing, gear cutting, drilling, screw making, punch work and other operations. The box goes to the first foreman having to do with the job in hand. When the operation in his department is completed, the box of partly finished pieces goes, not to the next operating department, but to the clearance house, from which it is routed to the inspectors and then on to the next process. So the routing of stock is handled by a distinct department which can carefully watch the progress of the work. In many ways, the clearance house performs the duties of a production department. In detail the system works out as follows:

After the raw stock has been inspected, the stock is ordered into the factory by the stock department on receipt of production order blanks (Form XXXV). The original of this form is sent to the foreman of the department which is concerned with the first operation on the stock.

Inspection goes hand in hand with the stock as it moves through the factory. Delivered from the main supply in boxes, each amount of stock has a separate and individual number. Going with each box, in the metal pocket on the side, is a stock order card (Form XXXVI) which accompanies the material on its way through the plant, as a means of identification by inspectors. Upon this card is entered all the data as to the amount of stock, time consumed on operation, price, pieces lost and workman's name.

The clearance house handles the accounting on all these items and a record of the progress of each box by number is kept on a clearance sheet (Form XXXVIII). When stock, for instance, is sent out to the machine shop, a record is made on both the stock order card and the clearance sheet. The former accompanies the

box of stock to the machine room. When the operation is finished, the stock together with the order card, or time ticket, as it is called, is returned to the clearance house. The clearance house clerks then enter all data from the time tickets on the clearance sheet.



A — Assembling No. 35
B — " No. 79
C — " No. 135
D — " B. A.
E — Bindery
F — Blacksmith Shop
G — Brass Room

H — Clearance House
I — Drill
J — Electrotype
K — Etching
L — Finished Castings
M — Indicated
N — Inspected

O — Drill No. 2
P — Mill No. 1
Q — Mill No. 2
R — Plating
S — Polishing
T — Punch
U — Screw

V — Stock
W — Tin Shop
X — Tool
Y —
Z —

Operation Number and Letter	Department Letters	Card Letter / Box Number / Due Date	No. Per Box	Date Chgd. Dept.	Date Chgd. Insp.	X — D	Cost per 100 Pieces	Card Letter / Box Number / Due Date	No. Per Box	Date Chgd. Dept.	Date Chgd. Insp.	X — D	Cost per 100 Pieces	Card Letter / Box Number / Due Date	No. Per Box	Date Chgd. Dept.	Date Chgd. Insp.	X — D	Cost per 100 Pieces	Card Letter / Box Number / Due Date	No. Per Box	Date Chgd. Dept.	Date Chgd. Insp.	X — D	Cost per 100 Pieces

Quantities Sent Ahead	Quantity	Date	Quantity	Date	Quantity	Date	Quantity	Date

Operations

Quantity Ordered	Name of Part			
Date Ordered	Kind of Material and Quality per 100 Pcs.	Material Cost per 100 Pcs.	Due Date	Order Number

FORM XXXVIII: On this clearance sheet is kept a record of the various operations through which each part passes. The data on this sheet is entered by the clearance house clerks. From these records costs are computed accurately on work passed by inspectors. The sheet forms a compact summary of operations

As soon as the time ticket has been entered and stamped by the clearance house clerk, it is sent with the box to the inspectors' benches. The parts are gaged by the inspector and the time ticket receives his O. K., lost or rejected pieces first being recorded on it. The workman is paid only for the amount of stock marked with the inspector's O. K.

The inspector then turns in the order card to another clerk in the clearance house, who enters on the clearance sheet the number of good pieces and the inspector's initials. From this form the work of clerks and inspectors can easily be checked.

After this inspection is concluded, the order card is returned to its box, and a moving ticket, or clearance house sheet, is placed with it (Form XXXVII). This moving ticket is made out

Piece Lost Report

CJ

Report One Item Only on a Sheet.
Color of Form and (X) after Name of Department
Indicates Where Loss Was Noted

Month	Day

Items Common to All Departments

Plate No.	Size	Pat. No.	Date Cast	M'f'd by	Defect (Ind. by No.)

Foundry ( )

Where Lost			Size Flask
Fl	Dum	Tr	

Cleaning Department (X)

Where Lost										Fd'y Disc't
Rt	1 B	H Cl	Cb	Fin	Gr	Dr	2 B	Tr		

Enameling Department ( )

Where Lost					Enameled			Inspection Change	
Fur	Tr	G C	En		Date	By	Fur No.	2nd	Cull

Packing Department ( )

Date En	En by	Fur No.	Where Lost					Inspection Change						
								Graded from			Graded to			
			Pal	Dec	Fit	Pak	Tr	1st	2nd	A. O. E.	Cull	2nd		1 En

Charge Back to

Name	No.	Position

Not Charged Back — Who to Blame

Name	No.	Position

Statements (Foreman or Inspector In Every Case Get Statement of Man)

Man No. _____

Signed _____

Man No. _____

Signed _____

Foreman _____

Signed _____ Position _____

Inspector _____

Signed _____ Location _____

Countersigned Chief Inspector	Referred to	Entered Payroll	Ent'd Recap. Losses

FORM XXXIX: This inspection form is notable for several reasons. The greater part of the information required on each piece thrown out can be recorded merely by a pencil check. By having spaces for all the departments, one design answers every purpose. For each of the four main departments, however, a different color is employed, with an identifying symbol

in duplicate. The original is sent to the foreman having to do with the next operation, and the duplicate is placed in the metal pocket on its box, along with the order card. When the foreman can do the job, he sends the original back to the clearance house. Acting on the moving ticket, properly signed, as an order, the clearance house clerk immediately sends the stock out to the foreman, while the order card is again properly entered to correspond with the operations. The clearance house sheet at the same time receives its additional data. The sheet is sent with the stock, then signed by the receiving foreman and returned to the clearance house.

Thus the clearance department is enabled to tell exactly where any stock is, the quantity on hand, the exact cost, the lost pieces, the workman's name and the price paid. For each class of machine built at the National Cash Register Company's plant, the order card has a distinctive color, so that the inspectors can tell at a glance where the stock is going. Every processing department does its part of the work by this same routine. The parts when finished go to the finished stock department.

The general inspection department works throughout the plant. Men in this section are distributed in the various departments. In the foundry, for example, all castings are submitted to a staff of three inspectors who reject imperfect pieces, charging them against the piecework molder and requiring him to make others. Every foundry man has his individual stamp, so that when the parts are examined in the inspection room, each rejected piece can be traced back to the proper molder, even though several may be turning out the same kind of casting. The castings accepted by the foundry inspectors are shipped to the finished stock-room.

When the finished parts are ordered into the assembling departments, the second stage of inspection is entered. The inspection routine for parts that are assembled in groups is like that for single parts. The inspection and routing service is maintained in all the assembling departments, but these, of course, are not as numerous as the processing departments.

The final inspection department is outside the authority of the works manager. This is an essential if quality is to be gaged independently and with fresh insight. If it were not, the

heads of assembling departments in their efforts to turn out a maximum number of machines might urge less searching inspection on the superintendent. But the final court of inspection, which accepts or rejects each machine, not only as to finish, but also mechanical accuracy, occupies a position outside the shops and familiar with trade considerations.

These are the detailed inspection methods of a big plant. In many factories, inspection can be handled more simply. It may sometimes be inexpedient, for example, to establish a clearance house. To do so might merely delay and complicate production. But the big plant is the microscope by which methods are perfected in detail and underlying principles developed. In the field of inspection, these principles from which no shop can wisely deviate are (1) standards; (2) unbiased comparison of work with standards; (3) such scheduling of inspection work upon single parts, assembled units and the finished product as will throw every imperfect piece out of the stream of production at the earliest possible moment.

QUALITY STANDARDS AND THE PROBLEM OF QUANTITY

BACK of inspection, of course, must stand accurate production. The inspector in any case is merely a critic. The standard which is used by inspectors must first guide the planning room in laying out the work, and the machinist in doing it. The inspection system and the production system need to be smoothly coordinated with identical standards expressed in the most definite practical terms. A "standard of quality," based upon nothing more than the pride of the manager who once worked at a bench, is merely a point of origin for blunders and disputes. Workmanship and inspection must be based on actual dimensions, weights, and tests of strength, durability, finish, chemical make-up and utility.

If quality be interpreted as fitness, as it should be, then a piece of work can be fit or unfit, well made or poorly made, true to standard or false to standard. A dimension may be inaccurate or a finish unsatisfactory. In uncovering the cause for poor quality, the manager sooner or later comes to the ques-

tion: "Is quantity production antagonistic to final quality?" The determination of the point at which quality, output and costs are all at their best is an important factor in establishing production standards. It should be made the subject of careful study and experiment. For quality standards are simply the expression of what the plant can do best.

Outside the factory, the customer is the supreme inspector. If his verdict is to continue favorable, production and inspection must at least keep pace with the efforts of the most painstaking competitors. It is often said nowadays, that articles manufactured under modern conditions wear poorly in comparison with the products of former times, made by hand from labor-wrought materials. A million-dollar concern recently discovered that a reputation for making goods which wear out quickly, as a means of forcing "repeat" business, may very quickly turn the public to competing lines.

For the judgment of the customer is the one which counts. If the "money back if not satisfied" idea cannot be used as capital by the sales department, safeguards to quality will have been futile.

Part II

COST-KEEPING METHODS

AUTHORITIES AND SOURCES

FOR PART II

Part II is contributed chiefly by Mr. Porter who has drawn on his own experience and that of many executives in installing cost systems. Credit for advice and suggestions is due Frank W. Birdseye of Arthur Young & Company, accountants.

Chapter VIII. Material was supplied in part for this chapter by James Logan, vice-president, United States Envelope Company.

Chapter IX. Particular reference is made to the plants of Clark Brothers, Belmont, N. Y., Baker-Vawter Company, Seymour Manufacturing Company, and the Kohler Company.

Chapters X and XI. The experience of the Kohler Company, among others, is drawn upon in these chapters.

Chapter XII. This chapter includes matter by J. W. Wiley, assistant secretary, the Meyercord Company. Reference is made to the methods followed by the Home Furniture Company of York, Pa., the Kohler Company, and the Seymour Manufacturing Company.

Chapter XIII. Contributed by Mr. Porter and John Watson. This chapter describes in detail cost-keeping methods in the plants of the Sterling Piano Company, the Kohler Company, Rathbone, Sard & Company, two furniture companies, and others.

VIII

FITTING A COST SYSTEM TO THE PLANT

COST systems, unlike commodities, cannot be purchased in open market ready to use. While the principles of cost finding are universal, and a certain uniformity is of great value in the comparison of data from different plants, the detailed application is different in almost every line. Only in plants that are narrowly competitive can essentially the same system be adopted, and even then it may wisely differ at certain points. What will be a proper system under any given set of conditions needs to be the special object of study by one who not only understands the principles, but also is fairly familiar with the peculiarities of the business, or has ample opportunity to become acquainted with them. A cost system is an intricate piece of special mechanism, and like all such machinery, must be designed carefully and built well, with the requirements of use always uppermost, if it is to stand up under service.

Not every manufacturing proposition in its existing state can be fitted with a finished cost system; conditions may not yet be sufficiently standard. This fact has an important bearing both on the kind of a system that ought to be attempted and the length of time it will take for installation. The farther along the line of specialization and standardization a factory is, the easier it will be to fit it with a system that will give not only costs but control. If conditions are adverse, it will be futile to try for detailed operational costs at first. But the basic plan should be so broad that the details can be added as conditions are rectified and a closer analysis becomes possible.

Many managers make the mistake of forcing the matter. They

know what constitutes a satisfactory cost, and knowing this, their conscience will not admit of half-way measures. But a cost system that runs counter to existing conditions creates a strong reaction. It must be installed by degrees and each advance step made thoroughly solid before another is attempted. Otherwise so much opposition, premeditated as well as unwitting, will be encountered from both foremen and men as to doom the reform. Much needless prejudice has been engendered against cost systems because of headlong attempts to change shop habits in stores accounting, methods of wage payment and details of charging and reporting costs.

SYSTEM VERSUS RED TAPE—HOW FAR DOES IT PAY TO GO IN CUTTING COSTS?

ANOTHER mistake sometimes made is to go into too great detail on items whose total cost does not warrant the expense involved. The value of detailed costs can hardly be over-emphasized and a cost system that skims over the surface is scarcely entitled to the name. But common sense does not endorse the spending of two dollars to trace a dollar. Cost reduction as well as cost finding is the purpose of cost figures. If the expense of getting the cost in its details is more than the saving afterwards realized through the better control that follows, the work is not warranted, except, perhaps, as a one-time measure to get a basis for estimates.

Often, too, cost systems are needlessly expensive in operation. In the beginning the cost is bound to be high, but as the system settles down to a definite routine, the expense of operation should not burden the business. If it still does so, the forms are probably too complicated, the clerical work is not carefully organized, the possible short-cut methods of recording, checking, posting, calculating and totalling are neglected, or, last but not least, the importance of a proper man to head the costing reform is not sufficiently realized. This last point is really the crux of the whole matter. A fighter is needed, one with the natural instinct for results and who will take as much pride in operating his department efficiently and economically as any other department head. The cost man should in fact be capable some day

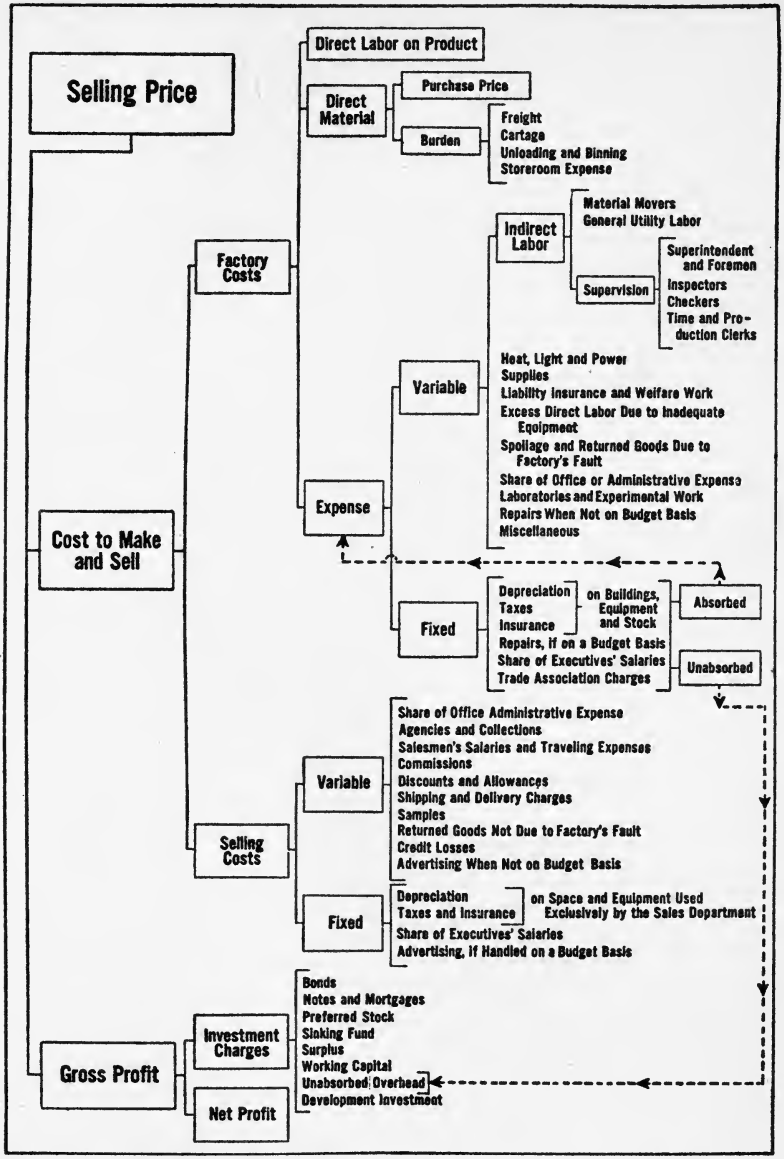


FIGURE VI: The selling price of any product analyzes into factory cost, composed of material, labor and expense; selling cost, and profit. Both factory and selling expense are subdivided into variable and fixed items. Unabsorbed or unearned overhead appears as a possible element of the investment—capital to bridge over dull times, interest charges on which reduce gross profits

of assuming the leadership of the organization, for his position rightly viewed is that of an assistant factory manager.

Many manufacturers have considered the advisability of installing proper cost accounting methods; but the expense involved has been a detriment. Viewing it as an expense is, however, a fallacy in most cases. A good cost system is an economy. So quickly does it produce results that in almost no instance have net profits failed to respond substantially within a period of six months from the date of installation. And when it does begin to show results, no part of the business pays so great and steady a return on the investment. Cost analysis in some lines of industry has done as much to reduce the cost of production during the past decade as mechanical inventions and improvements in the same period.

FIRST PRINCIPLES IN COST KEEPING—CONDITIONS ON WHICH SOUND COST CONTROL DEPENDS

AT the base of any proper accounting system is a clear and definite classification of the items of cost. Material is purchased at a certain price. Through labor done on it, value is added. This labor needs tools to work with, a substantial roof over its head and a certain amount of supervision and direction. It will also consume various materials in the course of manufacture which are not evident in the final product. It will further require the assistance of other labor, to maintain equipment and premises, move work, coordinate its activities and make proper records. These, too, cannot conveniently be ascribed to any producing operation. Then it will need the cooperation of other labor to market the product and collect the revenues therefor. Finally, to bridge the interval between payments made and payments received, a certain amount of surplus, or working capital, will be necessary under wise financial management. Every one of these items means money expended which is in addition to the value added to the original material by the actual labor applied to it. In some equitable manner, therefore, the direct labor cost of each article produced must be increased to take in all other charges.

How to classify various items of cost (Figure VI), both direct

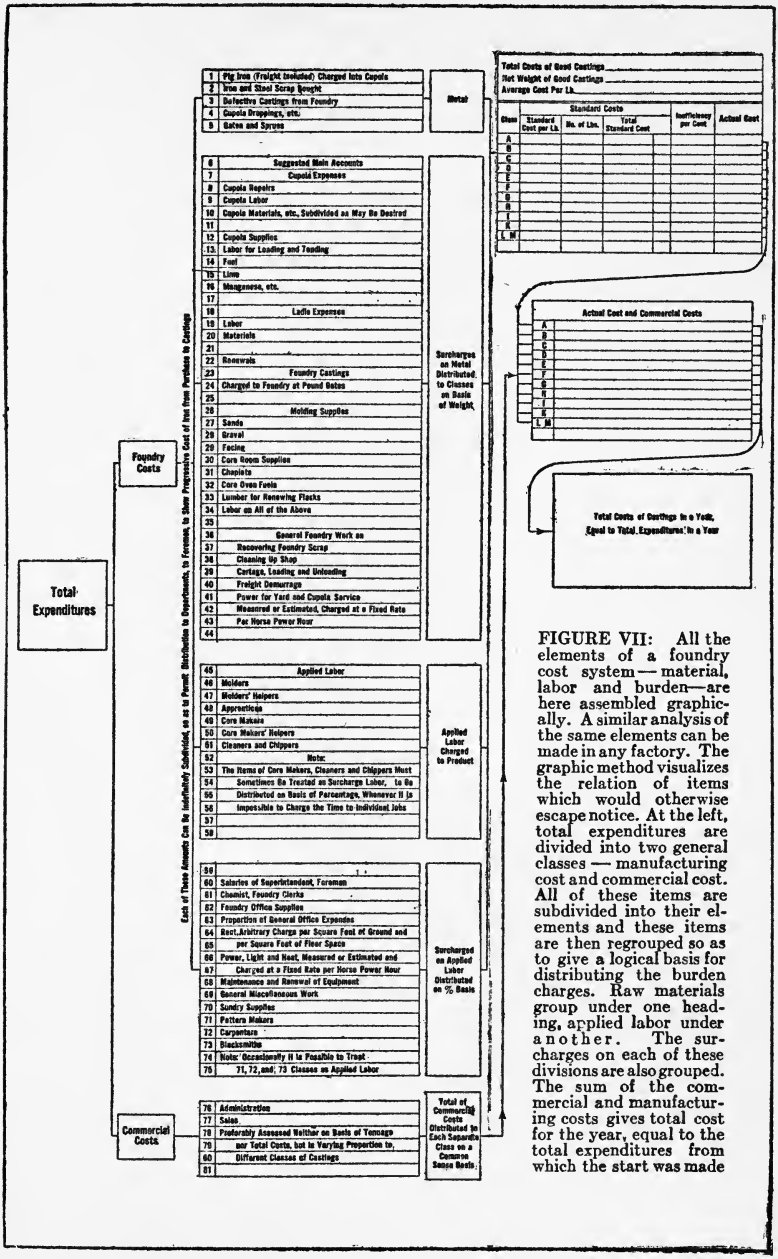


FIGURE VII: All the elements of a foundry cost system — material, labor and burden—are here assembled graphically. A similar analysis of the same elements can be made in any factory. The graphic method visualizes the relation of items which would otherwise escape notice. At the left, total expenditures are divided into two general classes — manufacturing cost and commercial cost. All of these items are subdivided into their elements and these items are then regrouped so as to give a logical basis for distributing the burden charges. Raw materials group under one heading, applied labor under another. The surcharges on each of these divisions are also grouped. The sum of the commercial and manufacturing costs gives total cost for the year, equal to the total expenditures from which the start was made

and indirect, how to collect and distribute them, and how finally to assemble the total cost will be told in the following chapters. As the cost system must rest on a solid foundation of physical facts, the way to determine the valuation of the fixed assets—buildings and equipment—is first described. To get the appraisal right is the initial step of cost installation. Then follows naturally the compilation of the fixed charges, and next the tabulation and distribution of the combined fixed charges and other overhead items, together commonly known by the term *manufacturing expense,* or simply *expense.*

This part of the work is usually laid out first, and in the meantime the system of collecting the labor and material charges is gradually perfected, so that when the labor cost is regularly reported the expense charges will be ready to combine with it. Often months elapse before this is possible, owing to the difficulty of getting accurate reports on operations, as well as a clean-cut division of direct from indirect charges. Only then does it become possible to bring out total costs. The first purpose of this work springs, of course, from the necessity of costs in estimating and pricing. At each step in building the system, however, the second principal purpose of cost keeping; namely, better control of the plant activities, is kept constantly in mind and the data arranged in such form as to convey to the busy executive an accurate picture of shop conditions.

Finally comes the proving of the cost totals. It is one matter to compile pretty summaries of estimated costs, quite another to be sure that the figures can be depended upon as a basis for selling prices. So the work of fitting a cost system to a business is not done until the factory accounting is interwoven with the general books and thus regularly proved. Only then can the management feel certain that prices cover costs and include a profit.

IX

LAYING THE BASIS FOR ACCURATE COSTS

FIRE recently destroyed an Eastern factory whose value was protected only partially by insurance. In the vault, fortunately, the records of the goods on hand—raw materials, supplies, finished stock and goods in process—survived intact. So the management, in making a settlement with the insurance companies, had no difficulty in arriving at a fair adjustment. But no record of the cost of plant and its equipment existed, except the very general record on the financial books. This was far from complete. There was almost no accounting for betterments and additions, and the company found itself more or less at the mercy of the adjusters. It was not in a position to question their arbitraments intelligently and with force. The awards, the factory heads felt, were not as liberal as they should have been; but they were powerless to combat the decisions. Naturally, the officers wished that they had been as systematic in keeping track of the valuation of their fixed property as of the materials of manufacture. An up-to-date running appraisal no doubt would have meant thousands of dollars to them in a better settlement.

Other concerns which have neglected this first principle of cost keeping have found themselves in similar predicaments. Not always is it a fire that discloses this need with the force of an emergency. Appraisals also are necessary as a basis for equitable taxation; to establish true earning capacity; to determine a proper capitalization; to fix the bonding limit; as a basis for reorganization, sale or transfer of the property; and as preparatory to remodeling or enlarging.

An accurate cost system is impossible without a correct and up-to-date physical valuation upon which to calculate the fixed charges. And when the other uses of such a valuation are considered, it may be said that there are many reasons for, and none against, the operation of a running appraisal. It is a basic practice of sound industrial management.

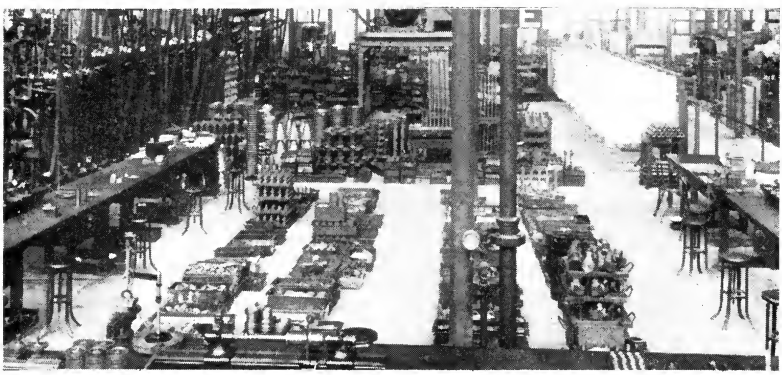
In fact, the keeping of a perpetual appraisal is in strict accord with the principle of carrying continuous card records of stock. And the proper starting point is at the beginning of the enterprise—otherwise many items that legitimately enter into the cost of construction and equipping, and should appear in every subsequent cost calculation, will be overlooked. Then, if from month to month and from year to year the value of improvements is added, and the records are corrected for appreciations, depreciations and changing price levels, the management always is prepared for whatever contingency may arise, not to mention the solid satisfaction meanwhile of having a rock-bottom basis for the cost system.

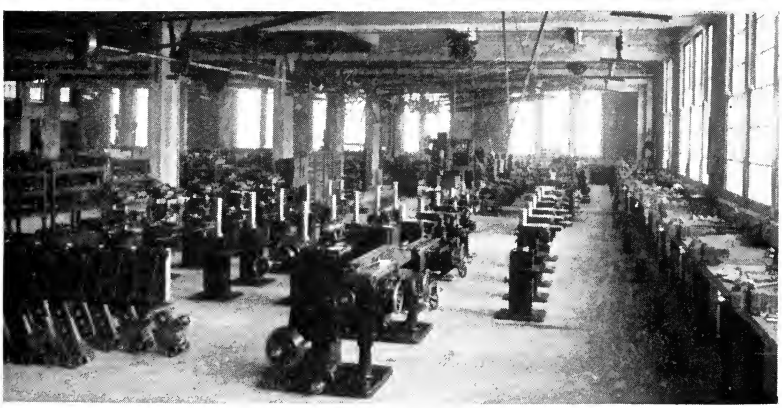
WHERE TO BEGIN IN GETTING AT THE AMOUNT OF CAPITAL INVESTED IN THE PLANT

IN making an appraisal the first step is to have an accurate plat of the property made, if none exists. The second is to have drawings prepared of the various structures, true to line, dimension and detail, and showing by some scheme of representation the location of all equipment. If such drawings already exist, this work is saved and the appraisers need only to check the accuracy of the existing plans.

To indicate where equipment is located will be much easier if a system of designation already is employed. If there is none, the factory manager will do well to detail one of his staff to join with the appraisers in working out a suitable scheme which will serve both their present purposes and the permanent uses of the factory.

As with stores, there are two systems in common use for designating equipment: one the mnemonic, or "aid-to-memory" system, wherein each piece of equipment is represented by a letter or combination of letters descriptive of the type and location;





Orderly methods safeguard quality. Above ivory keys are being inspected for whiteness under the tell-tale rays of the mercury vapor lamp. Note the careful arrangement of product in the inspection department of the Cincinnati Milling Machine Company (middle). In the assembly department (below), of the same plant gasoline for cleaning product is kept in cans near the benches

Standard quality requires standardized inspection methods. "Inspect product all along the line," is the rule of the National Cash Register Company. This is based on the fact that the farther defective work travels, the more expensive it becomes. Small parts inspection is shown in the upper picture, unit assembly inspection in the middle and final inspection below

the other the numerical system, where each piece is numbered consecutively. Both serve equally well the purposes of an appraisal. The mnemonic, however, has some advantages from the manufacturer's standpoint. Chief among these is the ease with which workmen memorize the characters.

If the numerical system is adopted, flexibility is imparted by numbering the equipment in series by departments, prefixing the letter or numeral designating the department to the machinery number. For instance, D-20 would indicate Machine No. 20 in Department D. As machines are added, the numbers in a department are kept together. This method of numbering also makes it easy to locate any piece of equipment without reference to a map or list, and, in this respect, ranks next to the mnemonic system as an aid to memory. Under the mnemonic, the same machine might be designated DMDP-1—No. 1 Multiple-Drill Press in Dept. D.

Appraisers, on the other hand, if left to themselves, are wont to number equipment up and down the factory without regard to use or location in departments. This may serve their purposes as well as any other system, but it is of no permanent use to the factory.

In connection with the cost system, the system of designating equipment is highly important. When it comes to figuring the overhead charges by departments, much difficulty will be experienced in picking out the different appraisal values if they are not already grouped logically. The appraisals records should be so arranged that a clerk with an adding machine can in a few minutes obtain the total equipment valuation in any department.

Once a system of designation has been worked out, the various pieces of equipment need to be marked in lasting fashion. One way is to mark the symbol on some conspicuous part in large characters with white or red paint. White is more conspicuous than red but less durable, requiring renewal more frequently. Neither is as satisfactory as a brass plate, in which the symbol has been cast or stamped, attached to the machine by means of screws. The brass plate method, of course, is more expensive, but the first cost is the only cost. It is unquestionably the ideal way of marking machines and motors. It is less well adapted to other equipment such as waste cans, pails and tote boxes. For

office furniture, such as desks, chairs and filing cabinets, small brass checks have been found suitable. At the Baker-Vawter plant still a different scheme is used. Here four-sided signs have been hung from overhead, and the machine designation is painted in white on a black background. The sign is very conspicuous and equally so from all angles.

TAKING THE ACTUAL INVENTORY WITH THE LEAST LABOR AND EXPENSE

WHEN the symbolizing of equipment is completed, the actual inventorying may begin. The usual procedure is to list each item in turn without attempting more than roughly to classify. One of the regular force can do this work as well as an outsider. As he takes each article the checker should mark it plainly with a piece of crayon. A second man, preferably one of the appraiser's staff, then makes an independent listing. He cancels the chalk line of the first man. If he finds a piece unmarked he makes a note of the fact. A third man—this time properly one of the appraisers—then takes these lists and compares them item for item. If they agree absolutely he approves them. If there are any discrepancies, or any items on one which are not on the other, he makes a personal investigation. His work, in short, is to reconcile any and all differences. This method insures the practical elimination of error.

In addition to jotting down the symbol, the checkers describe each article briefly, note the date and maker of machines (if visible) and remark on the general condition—how well the machine or other piece of equipment has been maintained and what per cent of the original service value remains, whether it is still an efficient type or so obsolete as to justify early replacement.

The work is facilitated greatly if a regular form is provided, with proper columns for the various items mentioned and, in addition, columns for unit prices and totals. Such a sheet is shown in Form XL. It is eight and a half by eleven in size and should have a sufficient margin at the left to allow fitting into a standard binder.

When the inventorying is completed and verified, the next step is to price the various articles. This is a task that requires

the close attention of an expert. Before finally fixing prices, however, it is customary for the appraisers to consult with the factory manager or his engineer, as doubt often exists about the accuracy of figures, which only one intimately acquainted with the business can remove.

LISTING SHEET

Date_____ Sheet No.____ of ____

Taken by_____ Priced by_____ Plant_____

Checked by_____ Checked by_____ Dept._____ Group_____

Quantity	Symbol or Description	Made by	Made Date	Remarks	Value Unit	Value Total

MACHINE RECORD

Machine No.	Location	Department	Description and Usage	No. Parts	Drawing No.

Maker	Maker's No.	Purchased of	Date Purchased	Cost	Remarks

Year	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
Inv. Value										
% Depreciation										

Date	Repairs	Cost	Date	Repairs	Cost

FORMS XL and XLI: The larger form, an 8½x11 sheet, allows space for the checker to note a description of machines and to describe their general conditions. Columns are supplied for the respective values which are to be added later. When running appraisals are operated, a record showing at all times the remaining service value in each machine is kept on the smaller form. This is similar to a perpetual inventory of stock where a separate card is allotted for each article

Appraisal of buildings and fixtures is an independent matter (Form XLII). If cost records are available, both of the original construction and of improvements, this part of the work

is much simplified. In the absence of actual figures, the only alternative is to prepare an estimate from the building plans. These, too, may be lacking or in poor shape, in which case new ones must first be drafted from actual measurements. An appraiser, in this event, with the assistance preferably of one or two young engineers or draftsmen, traverses the property with a field-book in hand, sketching therein the outline and principal details of the various structures, and noting dimensions. From these the plans quickly can be reproduced. It is then easy, by the ordinary process of taking off quantities for estimating—such as any contractor does in arriving at his tenders—to prepare the inventory of permanent structure. The appraiser, in making his rounds, takes note of the condition of the buildings, in detail and as a whole, and this information later is used in pricing quantities. Deferred maintenance also is recorded, to be taken into account in fixing present value.

It is not always necessary, nor invariably the practice, to go into complete detail in arriving at the value of buildings. Often it is possible to make a fairly accurate determination either by the square-foot-of-floor surface or the cubic-foot-of-contents method, using as a basis unit prices for similar structures, modified by a knowledge of local conditions, which may vary the average figure one way or the other, depending on whether in the particular locality structural materials and labor are higher or lower than the average.

Estimates by either of these methods usually include lighting, heating, plumbing and elevators—in short, the building and its fixtures complete.

If the appraisal is to serve not only for cost keeping, but also in determining the true capitalization or bonding limit, or as a basis for sale or transfer, then it must include also equipment and finished stock on hand and work in process (Figure XLIII). Building appraisals, if done in detail, may take the form of the classification shown in Form XLII.

To complete the valuation, a suitable amount to cover physical development charges must be added. These include all expense incurred prior to undertaking the actual work of construction, such as organization expense, the expense of financing the enterprise, city inspection, carrying charges, legal expenses, engi-

neering and contingencies, all of which are a legitimate part of the total valuation and are in addition to the estimated cost-to-reproduce-new. To cover these items a figure of twelve to fifteen per cent is commonly used. Such charges properly, it

ITEMS	COST TO REPRODUCE NEW	PRESENT VALUE
1. Excavation		
2. Material in Foundation		
3. Material in Walls		
4. Steel Frame (if any)		
5. Material in Floors (if Multi-story)		
6. Basement		
7. Roof		
8. Steel in Roof (if Supported by Steel Underbody)		
9. Windows and Doors		
10. Interior Finish		
11. Partitions Not Classed as Walls		
12. Coping and T. C. Trimmings		
13. Heating		
14. Plumbing		
15. Lighting		
16. Painting		
17. Elevators		
18. Miscellaneous		
19. Total of Items 1-18		
20. Add percentage to cover supervision or general contractor's profit		
21. Total Items 19 and 20		

ITEMS	COST TO REPRODUCE NEW	PRESENT VALUE
1. Power Plant (including dams and reservoirs, canals and penstocks, waterwheels and governors, boilers, engines, generators, air compressors, pumps, and so on)		
2. Transmissions		
3. Processing Equipment		
4. Maintenance Equipment		
5. Small Tools		
6. Miscellaneous Equipment		
7. Buildings and Structures		
8. Finished Stock on Hand		
9. Work in Process		
10. Miscellaneous		
11. Sum of Items 1-10		
12. Percentage to cover engineering, supervision, interest during construction, liability insurance, contingencies, and so on		
13. Total Items 11 and 12		
14. Office Furniture and Fixtures		
15. Motor Cars and Trucks, Wagons, Horses and Harness		
16. Raw Material and Supplies on Hand		
17. Real Estate, including fence, sewers, and so on		
18. Railroad Siding		
19. Sum of Items 14-18		
20. Total Items 13 and 19		

FORMS XLII and XLIII: The complete appraisal, including shipment and finished stock on hand and work in process, shapes itself as shown in the form at the left. If building appraisals are handled in detail, they may take the form shown at the right

should be said, ought to have been wiped out by absorption into the costs over a period of years; but if they have not been liquidated, it seems fair to allow something for them in the valuation.

Another debatable question is the proper pricing of real estate. Often the land on which a plant is located has so appreciated in value, through development of the vicinity, that it is worth more than the original price plus the plant valuation. Indeed, sometimes the appreciation is such that it pays to sell the prop-

erty, dismantle the plant and raze the buildings, and with the money realized build and equip a modern plant in another locality where land is still cheap. To include, then, the value of appreciated real estate in the valuation for cost purposes manifestly would be erroneous—unwise, in fact, as it would require such high prices for the output as seriously to handicap the business in competitive markets. The majority of court rulings and the concensus of opinion among experts are averse to including real estate appreciation. Instead, the tendency is to treat it as an earning on capital to be accumulated from year to year in the surplus and finally, upon sale of the property, to be paid as a deferred dividend. On the other hand, in such industries as coal mining and brick making, real estate is part of the assets which are being used up. In this case, a reserve must be set up for real estate depreciation.

Appreciation in value of materials, however, is held differently. Sometimes the latest market prices are taken; again the average price for the preceding three, four or five years. As to the exact prices used, this must be left largely to the judgment of the appraiser. If the intangibles are to be taken into consideration, the unit prices are modified accordingly, otherwise a fixed sum is added to the total. The unit prices used are on the basis of the sub-contracts and do not include the expense of supervision or general contractor's profit, for which an item of, say, ten per cent ordinarily is added to the total. The purely equipment items, however, are deducted when these have been installed under the manufacturer's own supervision, as the cost thereof then becomes a part of the machine valuation.

In arriving at the "present-value" or "worth-of-plant" at date of appraisal, depreciation and deferred maintenance (belated repairs) enter into the problem. A plant depreciates in value from the day it is occupied, and this depreciation increases with the years until the original value is largely wiped out. The minimum below which depreciation cannot sink is the *scrap* value. This is the figure which the materials and equipment would bring as junk, less the cost of removal. It is sometimes fixed at a fair market valuation or taken as some per cent, say, ten or fifteen, of the cost-to-reproduce-new. So long as use remains, however, there will be a minimum value higher than the

scrap value, below which the depreciation cannot go. This is called the salvage value and usually is twenty-five per cent of the original cost. The salvage or scrap value taken from the reproduction cost gives the working or original service value, upon which all depreciation must be based.

WHAT TO INCLUDE IN DEPRECIATION AND HOW TO FIGURE IT

DEPRECIATION includes all deterioration in value which cannot be made good by repairs—obsolescence, supersession, inadequacy, wear and tear. The original service value minus the depreciation gives what is termed the service value, and the service value plus the salvage or scrap value equals the present value. If there is any deferred maintenance, it forms, of course, a deduction from the present value; for it represents money that must be spent to make good the service value.

Depreciation is figured in two ways. Either a certain per cent of the original service value is deducted each year from the valuation, or a certain per cent of the depreciated value from year to year is taken. The first is called the "straight-line method;" the second, the "method of diminishing values." In the one, the entire valuation is wiped out in the course of time by successive equal decrements; in the other, the scrap or salvage value is approached as a limit by successively diminishing decrements but is never quite reached. Theoretically, the second is the more correct method; but the straight-line plan serves and is generally followed by factory accountants.

Depreciation is simply a device for absorbing into the costs the original investment over as long a term of years as practicable, so that when the original value is wiped off the books, the capital is restored intact, to be used in replacing the discarded items or applied to other betterment work. Usually the amounts thus set aside are charged into a depreciation-reserve account and the accumulation either borrowed from for the purposes of the business, deposited in savings banks, or invested in outside securities. There is little justification for any but the first practice, if the business otherwise would have to borrow from outside sources for working capital, since money invested in your own business usually pays a higher return than elsewhere.

No essential difference exists between this plan and the so-called "sinking-fund" method. In the latter, a certain predetermined amount is set aside from the surplus, or charged into the costs each year, which at compound interest will refund the original investment at the end of a certain term of years.

The wiping out of a liability, either by a reserve account or a sinking-fund, technically is known as "amortization." Salvage on discarded equipment forms a credit to the depreciation-reserve account. New equipment, or equipment not yet wiped out by depreciation, which is scrapped, is carried on the books until wiped out, minus the scrap or salvage value. The capital invested is then diminished accordingly. Depreciation is not charged on small tools, jigs, fixtures and packing, as such *supplies* are charged into current expense or to order costs.

Renewals, if to replace an article no longer capable of being made good by repairs, are chargeable against the depreciation reserve. If an improved article costing more is installed, however, the excess cost properly is chargeable to a Betterment, or Capital account—it is an added investment. All new equipment and buildings are also chargeable to betterment accounts.

No set rules exist for figuring depreciations. Many variables enter into the problem. Practice, however, has established certain percentages which serve as a guide to be used with judgment in particular cases. These percentages are, for buildings, from two to five per cent; for equipment, five to ten per cent and even, in special cases, as heavy as twenty per cent. Five per cent is usually taken for machine tools; ten per cent for power equipment. Two per cent is the figure commonly employed for concrete buildings; three to five per cent for structures of less durable materials. The per cent of depreciation is found by dividing one hundred by the life in years. Thus a depreciation of five per cent would mean an estimated usefulness of twenty years.

Such an appraisal indicates closely the working investment which the factory represents, and so constitutes the basis of production costs. Maintained as a running appraisal, with sound calculation of depreciation and additions, it supplies essential figures to the cost accounting year after year.

X

COMPILING FIXED CHARGES

BETTER factory construction is the rule every season in American industry, and even earlier types cost more to build now than a few years ago. More elaborate heating, ventilating and sanitary equipment is required. Needs for more automatic and hence higher priced machinery, and for totally *new* machines to replace hand operations, have made necessary an increasingly heavy investment in mechanical equipment. Land values have appreciated, and taxes have risen. Those operating expenses which are due to the capital investment have, therefore, gathered new significance with the years. The advent of scientific accounting methods, moreover, has awakened many to the fact that the capital charges which they perhaps were deeming unimportant and were either neglecting to figure at all or were covering by a "judgment" percentage totally inadequate, are in many industries one of the largest single elements of cost. In such plants, investment charges are now abnormally important, for they must make up lost time.

A simple illustration is furnished by the teaming business. Not many years ago horse vehicles for hauling purposes could be had in any number for three or four dollars a day of ten hours, including wages of the driver. Today the charge is from five to six dollars. Why? Because, chiefly, owners of teaming equipment are awakening to the significance of overhead. Formerly only the actual cost of upkeep, plus the driver's hire, was considered in fixing the price. The fact was largely ignored that money tied up in wagons, harnesses, horses and all the other fast-depreciating paraphernalia necessary in this business, in-

cluding stable room, was capable of earning a fixed return without risking the impairment of the principal or assuming the burden of management. A common justification for this was: "Oh, we are obliged to have these things anyway; besides, nobody else charges interest and upkeep." And these excuses have their counterpart in other businesses.

Consider these figures. A substantial wagon and harness will cost close to six hundred dollars, a good pair of draught horses another six hundred dollars. Accessories and stable facilities will add easily five hundred more, bringing the total investment up to seventeen hundred dollars. This at six per cent makes an interest charge of one hundred and two dollars annually. Allowing for bad weather and slack seasons, not more than two hundred working days in a year can be counted on. The daily interest charge hence will amount to fifty-one cents. To this must be added depreciation on live stock, at least fifteen per cent; on teaming equipment, twenty per cent; on structures, ten per cent; or, say, an average of fifteen per cent on the aggregate investment, making a total daily depreciation charge of $1.28. Repairs will average at least fifty cents more daily; care of horses seventy-five cents, insurance twenty-five cents, attendance two dollars. Thus the grand total daily cost will be $5.29. So the man who hires out a pair of horses and a wagon for less than five dollars a day receives practically nothing on his investment, let alone a reward for his enterprise, and at six dollars a day the return is only about fifteen per cent.

In this instance the fixed charges aggregate $2.04, or over thirty-eight per cent of the total cost. While the proportion of such charges in the average manufacturing establishment is seldom so high, it is never so small as to warrant either makeshift methods of distributing it, or indifference as to the total. Large or small in relation to the total costs of production, as that part of expense which is unescapable and which goes on hourly and daily whether the factory is running full or slack, or is totally idle, fixed charges require some equitable plan of distribution.

Fixed items of expense, strictly speaking, do not exist. Only in a relative or temporary sense may any expense be regarded as invariable. Take interest on investment. While the

capital remains the same, this charge is constant. But the investment is continually changing as new equipment is added, buildings are extended and the quantity of stores on hand diminishes or increases. Moreover, the interest rate itself is a variable. So then, interest charges—the most fixed of all fixed charges—are not, in the absolute sense, fixed at all. Relatively they may become even more variable as through more intensive utilization of space and equipment the volume of business increases. The same is true of depreciation, taxes and property insurance, all of which maintain a more or less definite ratio to the amount of capital being used at any given time. Depreciation, if any, is entitled most to classification as a variable, since it depends considerably on the character of maintenance as well as the judgment shown in purchasing, and these are matters of management. In an accounting sense, however, it is correct to consider all these things as fixed expenditures. They are *fixed* because they accrue hourly and daily whether the factory is doing business or not.

Repairs, for accounting purposes, also are often classified similarly, especially of buildings, as regardless of plant activity buildings need about so much attention. The advantage of handling repairs in this way is that each month then bears an equal burden. If they are handled as variables and are charged as they are incurred, one month will carry a heavy charge, the next one perhaps none at all. Equipment repairs are somewhat different, as these depend more largely on the character and amount of use. Therefore, it is probably better in the average case to charge them currently.

HOW TO PUT A FAIR BURDEN OF FIXED CHARGES ON EACH UNIT OF PRODUCT

IT IS one thing to determine what are fixed charges; quite another to arrange for their equitable distribution. The aim is to have each unit of the product bear its due and proper proportion of the total.

Before any plan of distribution can be formulated, it is first necessary to determine on a logical division of the business into departments, or correlated centers of production. This division

is often very carelessly done, without regard to the logic of the situation. Because certain groups of operations are housed within the same four walls, it does not follow necessarily that they are a department, in the accounting sense. Some may involve the use of costly machinery, others require little or no equipment. Bench or hand operations need to be separate from wholly machine operations. A piece of especially costly equipment, as an automatic glue jointer in a woodworking factory or a heavy drop press in a sheet-metal plant or the cupola in a foundry, is a department in itself. It is improper to class a battery of grinding machines with a group of drill presses, because the one is a heavy user of expensive materials while the other is not. A group of automatic screw machines, punch presses, engine lathes, looms or furnaces forms a natural department. Dissimilar units but not differing widely in cost, as woodworking machines in a mill room or shoe machinery, may on the other hand be grouped together without sacrificing practical accuracy. So the first step is to work out these natural groupings. At the same time the floor space occupied by each may well be determined.

When this is done find the total value of the equipment in each such department. Sometimes an appraisal may be necessary, as already outlined in the previous chapter. If the inventory of plant and equipment has been indifferently kept, and cannot easily be subdivided and adjusted for depreciation and additions, then by all means this expert valuation is needed. Otherwise the foundation of your entire cost system will be unsound.

Thereafter, the wise policy is to operate a running appraisal. At the beginning of each year, the fixed charges under this plan can easily be readjusted to date.

These charges divide naturally into two classes—space charges and equipment charges. The first distributes most accurately on the square foot of floor area; the second on the value basis. Thus the charges on the structure itself class as space charges, while those on the machinery fall into the value division.

For practical purposes it is correct to consider both kinds of charges as unvarying throughout any given fiscal year. Additions in the meantime will cause a slight error, but whatever

Expense Analysis Sheet — Fixed Charges

Item Buildings Value $9,000.00 Depreciation 5% Period Monthly Year 7/13 — 7/14

Part	Area Sq. Ft.	Wt.	Weighted Area Sq. Ft.	Prop. of Total %	Interest 6%	Depreciation 5%	Total Interest and Depreciation Year	Total Interest and Depreciation Month	Insurance	Taxes	Total Insurance and Taxes Year	Total Insurance and Taxes Month	Administration Year	Administration Month	Repairs (Estimated) Year	Repairs (Estimated) Month	Total Year	Total Month
Plant	9,000		11,000	100.00	$540.00	$450.00	$990.00	$82.50	$40.00	$180.00	$220.00	$18.33	$2,000.00	$166.67	$270.00	$22.50	$3,480.00	$290.00
Dept. A	1,600	1	1,600	14.30	79.00	65.60	144.60	12.05	5.83	26.30	32.13	2.68	292.00	24.33	39.40	3.28	508.03	42.336
" B	2,000	2	4,000	36.45	193.75	161.90	355.65	29.63	14.26	65.10	79.36	6.61	726.50	60.55	97.30	8.11	1,258.85	104.900
" C	3,000	1	3,000	27.37	148.75	123.70	272.45	22.71	11.06	49.20	60.26	5.02	544.00	45.33	74.20	6.18	950.95	79.241
" D	2,400	1	2,400	21.85	118.50	98.80	217.30	18.11	8.85	39.40	48.25	4.02	437.50	36.46	59.10	4.93	762.18	63.514
" E																		
" M																		
" N																		
Totals	9,000		11,000	100.00	$540.00	$450.00	$990.00	$82.50	$40.00	$180.00	$220.00	$18.33	$2,000.00	$166.67	$270.00	$22.50	$3,480.00	$290.00
Monthly					$45.00	$37.50		$6.88										

Expense Analysis Sheet — Fixed Charges

Item Equipment Value $100,000.00 Depreciation 10% average Period Monthly Year 7/13 — 7/14

Part	Equipment Value	Wt.	Weighted Value	Prop. of Total %	Interest 6%	Depreciation 10%	Total Interest and Depreciation Year	Total Interest and Depreciation Month	Insurance	Special Insurance	Taxes	Total Insurance and Taxes Year	Total Insurance and Taxes Month	Repairs (Estimated) Year	Repairs (Estimated) Month	Total Year	Total Month
Plant	$100,000.00		$110,000.00	100.00	$6,000.00	$11,000.00	$17,000.00	$1,416.67	$450.00	$20.00	$2,000.00	$2,470.00	$205.83	$1,000.00	$83.33	$20,470.00	$1,705.84
Dept. A	10,000.00	2	20,000.00	18.1⅓	1,089.00	1,990.00	3,079.00	256.58	81.46		962.00	443.46	36.97	181.00	15.08	3,703.46	308.695
" B	20,000.00	1	20,000.00	18.1⅓	1,089.00	1,990.00	3,079.00	256.58	81.67	20.00	362.00	463.67	38.64	181.00	15.08	3,723.67	310.315
" C	50,000.00	1	50,000.00	45.60	2,733.00	5,030.00	7,763.00	646.73	206.00		914.00	1,119.00	93.25	457.00	38.09	9,339.00	778.285
" D	20,000.00	1	20,000.00	18.1⅓	1,089.00	1,990.00	3,079.00	256.58	81.67		362.00	443.67	36.97	181.00	15.08	3,703.67	308.636
" E																	
" M																	
" N																	
Totals	$100,000.00		$110,000.00	100.00	$6,000.00	$11,000.00	$17,000.00	$1,416.67	$450.00	$20.00	$2,000.00	$2,470.00	$205.83	$1,000.00	$83.33	$20,470.00	$1,705.84
Monthly					$500.00	$833.33		$118.05									

FORMS XLIV and XLV: Each department bears a portion of the fixed charges against buildings, determined on the basis of the square feet of floor space occupied, and also a proportion of equipment charges, determined on the basis of departmental investment. Departments B and A are "weighted" to equalize the distribution. In distributing equipment charges, ten per cent is taken as the average fair depreciation charge throughout

the discrepancy, it is easily handled through adjustment accounts.

Having determined the charges for the ensuing year, you will next need to divide them by the number of book-closing periods, in order to arrive at the monthly or period charges to assess against the costs. Monthly closings are now general. A more scientific division is into thirteen periods of four weeks each, the objection to which of course is that it is out of accord with the calendar. Where the payroll is weekly, this plan is, however, entirely practical, but where payment is bi-monthly, the twelve-period division gives accurate comparisons. In some lines of business even quarterly closings may answer every purpose. It all depends on how rapidly the material is turned over. But the twelve or thirteen-period division meets the conditions in the majority of cases.

You are now ready to draw up the distribution sheets of fixed charges. List the departments at the left (Form XLIV), place after each its share of the floor space, find the proportion of each to the total area and set down the percentages in the third column. If some of the departments occupy more valuable space than the rest, then it is first necessary to weight the areas according to their relative values. For instance, if department A is quartered in a building worth a dollar a square foot, while the value of the space in the rest of the plant is only fifty cents a square foot, then in arriving at the total area upon which to base apportionment, area A needs to be taken twice.

As will be seen from Form XLIV, the share of the various fixed charges—interest on investment, depreciation, taxes and insurance—to assess against each department is then obtained by multiplying the total amounts of each by the various department percentages.

Columns also are shown for administrative expense and for repairs. What will be the bill for repairs can of course only be approximated. At the end of the year the aggregate may be greater or less than you have assumed. Whichever way the difference lies, it is easily disposed of through profit and loss or, better, by distributing it over the ensuing year as an increment or a decrement to the previous monthly or period charge. The other way, charging into the costs only the actual expense

incurred for repairs in any month, means that the amounts will vary widely from month to month and thus accentuate the fluctuation in your costs.

This disposes of that portion of the fixed charges that distributes on a space basis. On the right hand of the same sheet, or on a similar one (Form XLV), next line up the value charges in the same manner. List opposite each department the total value of the equipment therein. Find the percentage of each to the sum and apportion the equipment interest, depreciation, taxes and insurance accordingly. If one department houses machinery that depreciates more rapidly than the average, it is of course necessary to weight it as before. For if it depreciates, say, twice as rapidly, then it is no more than just that it bear its proportionately greater share of interest, taxes and insurance as well as its entire abnormal burden of depreciation. This is the same as considering that it represents twice as much investment. In the example given, ten per cent is taken for the average depreciation, while twenty per cent is assumed for Department A.

Again, the equipment in one department may involve an unusual accident hazard, as flywheels in a power house or some process using explosive materials, for which a special insurance is carried. The tax for this insurance obviously is a separate charge against that particular department. Department B in the example given is assumed to have such a risk and has an extra charge of twenty dollars.

On the sheets shown, the apportionment has first been made on a yearly basis, then the several department totals divided by twelve (or the number of closing periods chosen). This has been done to promote accuracy in calculation, as many of the amounts are small. The monthly or period totals might just as well have been taken and thus the final cross totals made to represent the monthly charges, without a further operation of division. It is obviously immaterial which way it is done—the end is the same.

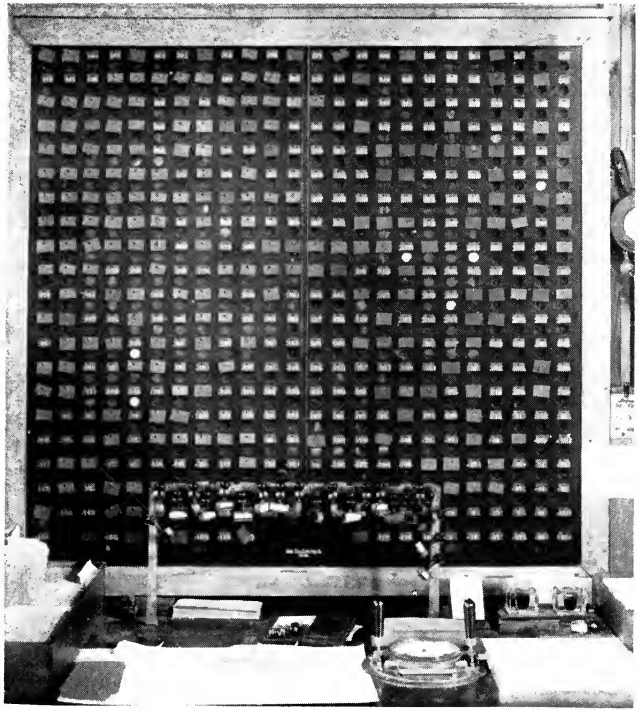
XI

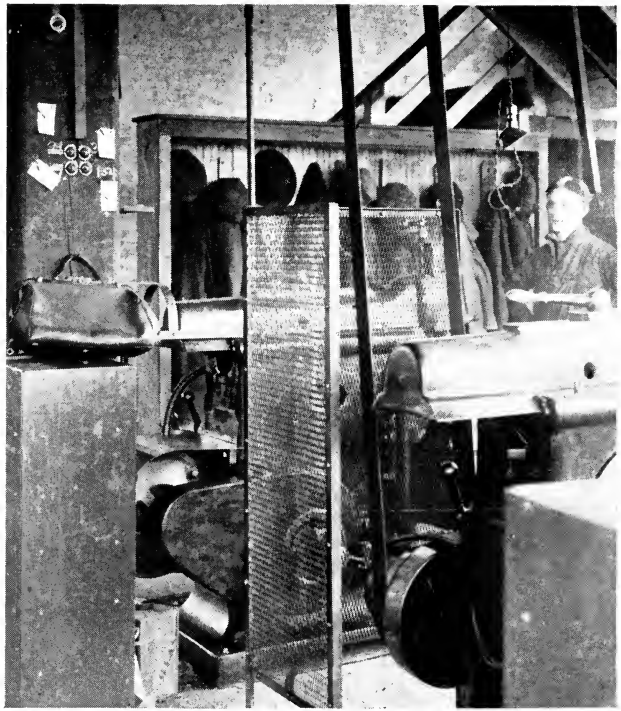
EXPENSE ANALYSIS AND DISTRIBUTION

MANUFACTURING expense, or burden, comprises all those items of expenditure which cannot be assessed directly against the unit of production, but must be distributed, or prorated over the direct cost in such a manner that each unit bears its just and proper proportion of the total. It includes both fixed charges, discussed in the preceding chapter, and such other items of expense as the current activity of the plant entails. These other items are commonly known as the *variables* of expense (Figure VI), because they vary with the volume of business and cease altogether when the plant shuts down. They are also called *controllables,* as distinguished from uncontrollable, or fixed expenses, because in the average case good management can reduce them.

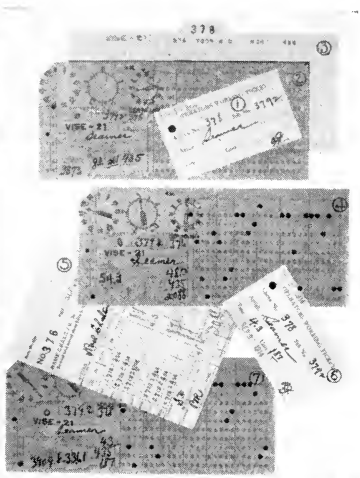
In compiling the variables of expense, therefore, two purposes must be kept in mind. One is to arrive at some ratio or charge which can be annexed conveniently to the direct charges—applied labor and material, and which with practical accuracy completes the cost. The other is to throw the figures into such comparative form that the busy manager can note the fluctuations from month to month and so focus on reducing excessive items. In other words, one purpose is cost finding, the other cost control.

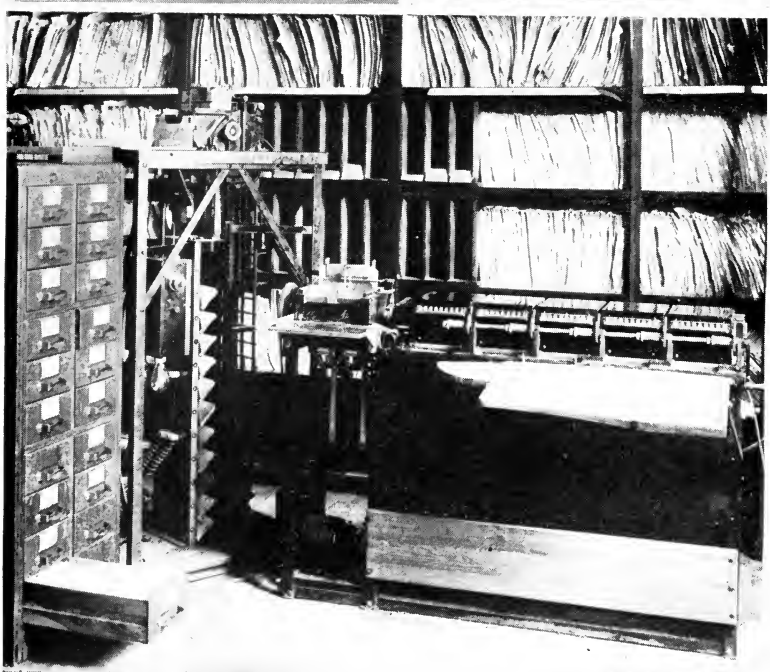
As in preparing the sheet of fixed charges the logical division of the plant into departments is assumed to have been accomplished, the next step is to lay out for each department an expense analysis sheet, as mentioned in the previous chapter. A convenient and much used design for this is shown in Form XLVI.





In an Illinois plant, costs are recorded by machinery, as shown on this and the next page. Not over seven feet from each machine is a push button (right), which connects with the central time clerk's annunciator (left). When the individual workmen start and stop jobs this fact is signalled on the annunciator. Three thousand dollars a year is saved by the installation of this system





A complete record of the labor cost is made from a set of cards (upper right), filled in from the information flashed on the annunciator. The cost of materials is kept on a separate set of cards. The telephone operator punches the cards for the tabulating machine and mechanical sorter shown below. Job labor cost only is recorded by the annunciator. Payroll time is recorded by the clocks

At the left is a wide column for the items of expense, both fixed and variable. If these, in common with the buildings, departments, machines, tools, and stores, have been symbolized, as indeed they may well be to save clerical work, a much narrower column will answer. Next is a column for the last year's total, and another for the average month of the year previous—valuable as a standard of comparison. Then follow a series of double or triple columns for the months of the year, in the first of which the figures for the month are set down and in the second, the cumulative totals to date. With the second series, a column is added to carry the average month to date.

Sometimes before the double columns begin, another single column is interposed for the estimated average monthly figures, or appropriated expense. When sufficient time has elapsed to set up standards for the various items, this column may well be added to establish a quota. Again, four instead of three columns are sometimes provided in the sections that follow, the additional column being for the "Same-Month-Last-Year." To get every possible comparison, still another column may be provided, for the "Last-Year-to-Date." The month's expense may then be compared with the same month the preceding year, the average month last year, and the estimated average for the current year; and the period totals with the corresponding totals of the year before. Such a complete presentation may be extremely helpful in some businesses, and probably worth while eventually in every case; but in the beginning the simpler form usually will answer every requirement.

In figuring costs the first month of a new year, the ratio of expense or hourly charge to combine with the direct, flat or prime cost, is based on this month's expense. Thereafter, the period-to-date totals are taken. Thus an increasingly equalized ratio or charge is obtained and monthly fluctuations are discounted; a more stable cost results.

Sheets for the auxiliary departments—as the office, power house, pattern shop, and construction and repairs departments, which are necessary to the operation of the plant, but do not actually work on the product—are made out first, as these must be absorbed into the manufacturing departments proper. These do not, however, provide for all the expense that cannot

be assessed directly against a producing department. Overlaying all are certain general items—general supervision, general clerical, general yard and general utility labor, watchmen, liability insurance, supplies used about the premises as a whole, receiving labor, incoming freight and cartage and storeroom expenses—which must first of all be assembled and distributed in such a manner that each department, direct or indirect,

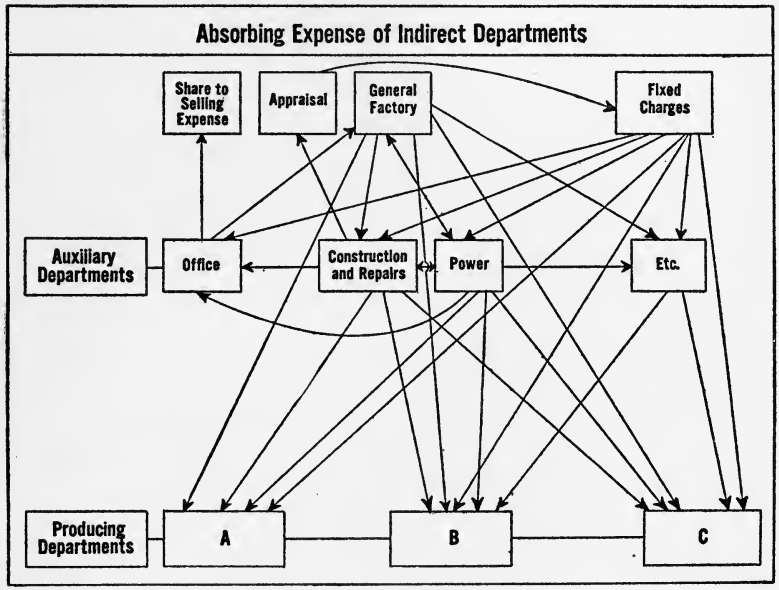


FIGURE VIII: All expense must eventually be shouldered by the producing departments. General factory overlays all departments, as does power, construction and repairs, and fixed charges. General factory absorbs office expense and is in turn absorbed by the other departments, usually according to direct labor. Power is distributed according to use, construction and repairs, as shown by the material and labor reports, fixed charges on a basis of space and equipment values in the several departments. The accuracy of distribution depends on the care with which the producing operations are grouped to form departments

receives its proper share of the total. Office, or administrative expense, too, is most conveniently handled as a part of general expense, although it is compiled on a separate sheet, as a share of it properly is chargeable to commercial, or selling expense (Figure VIII). In charging a department like office, which is absorbed into general factory expense, with its prorata of another auxiliary department, say "Power," which also takes a share

of the general factory total, the per cent to cover the factory total is not added to the office charge.

Shipping expense is another item sometimes charged to general factory expense, but prevailing practice treats it as an element of selling expense. Which is proper is determined largely by your manufacturing problem. If you are making to stock and shipping is more or less intermittent, then this item is unquestionably a selling expense. But if, like Ford, you ship out parts as fast as they are produced, to assembly plants in other cities, the reverse practice is probably better. It all depends on where you consider production to end and distribution to begin.

Incoming freight and cartage is another debatable item. The simplest way, of course, is to handle it through general factory expense. Adding it directly to the material cost is, however, more accurate (Figure VI). The cost of a car of coal, lumber or pig iron, for instance, is not the price f. o. b. the shipping point, but the cost actually delivered. Some even add unloading and binning charges. Coal always may best be so handled, but when there is no great diversity in the factory's supply, accounting certainly is simplified and accuracy not seriously sacrificed by charging transportation to general factory expense.

A similar line of reasoning applies to storeroom expense. This is absorbed most simply through general factory. In case of a finished stock storage, in a strictly stock manufacture, so to do is also accurate. A raw material or a supply storage serving one department would be a charge against the specific expense of that department, not against the factory general; while a storeroom catering to a number of associated departments—each of which produced a finished product independently—would have its expense distributed among those departments in the ratio of the value of stores issued to each. What is the proper way to handle this item in a given case thus depends altogether on conditions.

PROBLEMS INVOLVED IN THE DISTRIBUTION OF FACTORY GENERAL EXPENSE

AGAIN, a diversity in practice also exists on the point of the indirect departments assuming any of the factory general. In a management sense it is hard to see why indirect as well as

EXPENSE

DEPARTMENT Office

ITEM	LAST YEAR TOTAL	AV. MONTH LAST YEAR	MONTH ENDING Jan 1914	MONTH ENDING Feb 1914	YEAR TO DATE	MONTH ENDING March	YEAR TO DATE
Executives	1620 00	1350 00	1435 00	1435 00	2870 00	1435 00	4305 00
Postage	840 00	70 00	75 00	69 00	144 00	76 50	220 50
Printing + Stationery	660 00	55 00	67 50	50 20	117 70	36 90	154 60
Clerks + Juniors	6000 00	500 00	527 00	480 00	1007 00	520 00	1527 00
Telephone + Telegraphs	102 00	8 50	7 93	6 80	14 73	7 10	21 83
Donations	60 00	5 00	10 00	5 00	15 00	2 00	17 00
Advertising General	1800 00	150 00	173 90	140 50	314 40	148 80	469 20
Association Dues	300 00	25 00	25 00	25 00	50 00	25 00	75 00
Fixed Charges							
Insurance	105 60	8 80	9 16	9 16	18 32	9 16	27 48
Taxes	47 40	3 95	4 17	4 17	8 34	4 17	12 51
Depreciation	116 04	9 67	10 08	10 08	20 16	10 08	30 24
Rent	23 28	1 94	1 94	1 94	3 88	1 94	5 82
Power, Heat + Light	72 36	6 03	5 61	5 20	10 81	5 00	15 81
Total Expense - Month		2193 89	2352 29	2242 05		2281 65	
Total Expense - Period	26326 68				4594 34		6875 99
To Selling Exp. - 60.%	15996 01	1316 35	1411 37	1345 23	2756 60	1368 99	3525 59
To Gen'l Factory Exp. - 40 %	10330 67	877 54	940 92	896 82	1837 74	912 66	2350 40

FORM XLVI: An expense analysis sheet, like the one shown above and on the next page, for showing comparisons, is prepared for each department in one factory. Front and reverse cover the entire year. Various expense items are given for the month and in an adjacent column for the period

direct departments should not bear their fair share of the general burden. On the other hand, the producing departments have to shoulder it all in the end anyhow. Hence why not distribute all of general factory directly to these departments? So the adverse argument runs, and this way certainly has accounting ease in its favor. The manufacturer may decide for himself. If his auxiliary departments are unimportant and he buys his power, then the simpler method is the one to adopt. If, however, he has an expensive power plant and a large construction and repair department where he builds much special equipment, it certainly would be a mistake not to charge the indirect departments with their fair share of all burden. Suppose he sold some of his power; then he would be cheating himself if for the sake of an accounting short cut he let the power house off. Distributing all of general factory to the producing departments, on the other hand, avoids the complexity that arises under the other method, due to the fact that an auxiliary department may contribute to the total of general factory. To

ANALYSIS

FROM Jan 1st 1914 TO July 1st 1914

AVERAGE MONTH TO DATE	MONTH ENDING April	YEAR TO DATE	AVERAGE MONTH TO DATE	MONTH ENDING May	YEAR TO DATE	AVERAGE MONTH TO DATE	MONTH ENDING June	YEAR TO DATE	AVERAGE MONTH TO DATE
1435 00	1435 00	5740 00	1435 00	1435 00	7175 00	1435 00	1435 00	8610 00	1435 00
73 50	81 25	301 75	75 44	72 00	376 75	73 35	82 00	456 75	76 12
51 53	72 00	226 60	56 65	29 46	256 00	51 20	40 60	296 60	49 43
509 00	514 50	2041 50	510 37	540 10	2581 50	516 30	550 00	3131 50	521 92
7 28	8 30	30 13	7 53	9 00	39 13	7 83	8 50	47 63	7 94
5 67	18 00	32 00	8 00	6 00	38 00	7 60	4 00	42 00	7 00
154 40	190 40	653 60	163 40	200 00	853 60	170 72	165 00	1018 60	169 77
25 00	25 00	100 00	25 00	25 00	125 00	25 00	25 00	150 00	25 00
9 16	9 16	36 64	9 16	9 16	45 80	9 16	9 16	54 96	9 16
4 17	4 17	16 68	4 17	4 17	20 85	4 17	4 17	25 02	4 17
10 09	10 08	40 32	10 08	10 08	50 40	10 08	10 08	60 48	10 08
1 94	1 94	7 76	1 94	1 94	9 70	1 94	1 94	11 64	1 94
5 27	5 10	20 91	5 23	4 80	25 71	5 14	4 60	30 31	5 05
2292 00	2371 90		2311 97	2346 55		2319 49	2338 05		2322 58
		9249 89			11597 44			13935 49	
1375 20	1423 14	5548 73	1387 18	1409 93	6958 96	1391 69	1402 83	8361 29	1393 55
916 80	948 76	3699 16	924 79	938 62	4636 98	927 80	935 22	5514 20	919 03

to date. Also the average month to date is given. For the alert executive this tabulation forms an effective means of comparison and guidance not only in cutting down expense, but in standardizing similar items of cost throughout the departments of the factory

redistribute a portion of general factory to it, therefore, makes an awkward accounting problem.

Factory general expense is distributed to the various departments most commonly on the basis of the direct labor. That is, if one department has a direct labor payroll of $1,000 and the total direct labor payroll is $10,000, this department takes one-tenth of the general burden. It also is sometimes prorated in the ratio of the floor space, a department occupying one-tenth of the total area taking this proportion of the expense. Again, it may be apportioned according to the number of direct-labor hours. If the department expense is so distributed, then of course the general expense should be similarly handled. Only an analysis of conditions in a given case can determine which of these ways or some other—a quantity basis, for instance—will be closest to the truth.

Power expense is distributed to the departments using power on actual measurement from the switchboard, in case transmission is electrical. A less accurate way is on the basis of the rated horsepower of the machines in the different departments.

When the plant is driven from a line-shaft, this may indeed be the only practicable method. In plants where each department has its own engine, supplied with steam from a central boiler plant, the use of steam-flow meters affords the only accurate means.

Heat and light are often grouped with power, but there are cases where so to do would work a considerable inaccuracy. Electric lighting can easily be measured, if each department is on a separate circuit. Its expense can at least be distributed with fair accuracy on some arbitrary basis. The watts in each department multiplied by the average hours of use furnishes a fairly good gage. Heating expense is most easily distributed on a space basis. If some of the ceilings are especially high, a corrective factor is of course necessary. So, too, if there is any wide difference in the temperature required, to be absolutely accurate, correction should likewise be made for variance in the character of exposure. A single-story building or a top story, for instance, requires more heat units than a between story. The relative amount of window exposure, and the thickness and material of the walls also make a difference. Seldom, however, is the bill for heating of sufficient importance, as compared to the total expense, to warrant hair-splitting methods of distribution. The floor area corrected by the story height, or the cubic-feet of air space gives adequate results, if indeed in the average case you need to consider heating separate from power at all.

Repairs, if made by the construction and repair department, are charged to the other departments on the indication of the material and labor tickets of this department. The department overhead is added usually as a per cent of the direct labor. What of the expense of this department is not thus accounted for, since it is applied to betterment work, is charged to betterment, or asset accounts, to make its way into expense as a fixed charge. General factory is not added to that portion of the construction and repair expense incurred in behalf of general factory.

Before coming to the department analysis sheets, certain group general sheets may be necessary. Often contiguous departments have a common supervision, inspection, maintenance and clerical

force, also space which cannot justly be charged against any one. Such a situation requires a group general analysis sheet. This sheet then takes the share of factory general due the departments in the group, and this in turn is distributed over these departments, usually on the basis of the direct labor.

Each subsidiary sheet—indirect or group general, at any rate—after the various items of fixed and current expenses have been entered, is totalled and the distribution of the sum placed at the bottom. Thus all items of expense not directly chargeable against any producing department are put in shape for posting forward to the expense analysis sheets of these.

So, then, when the sheet of a producing department is completed, with its share of factory general or group general, share of power, heat and light, share of repairs and in addition its own fixed charges, indirect labor, supervision, spoilage, supplies, lamp renewals and other current expenses, the sum represents every possible item of expense incurred by, or in behalf of the department in question. Add to this the direct labor payroll for the month and you have the total cost of operation minus the material cost, or the amount by which the material processed that month has been increased in value.

One more step remains—to express the total department expense in the form of a ratio or hourly charge which can be applied to the direct (or prime) cost and which will complete it.

No hard and fast rule can be laid down for combining the direct and indirect cost items. Some, following merchandising practice, add manufacturing expense as a per cent of the combined labor and material cost. While this method is correct as regards selling expense, haphazard use of it in factory accounting has led to some very absurd results. It is only safe to follow when the factory makes one standard product or several that are uniform in material, and approximately uniform in size and amount of work required. Even then it is probably better in the average case to establish the expense as a per cent of the direct labor.

This method of distribution is perhaps the simplest and the most generally employed. Those who advocate it do so on the ground that all expense is incurred on behalf of the direct, or

producing labor—to keep this labor occupied, and that, therefore, the expense will vary pretty closely with the amount of direct labor. And many times this allocation of expense is equitable. It would be, for instance, in a department where machines are practically identical and all operatives earn about the same wages.

On the other hand, if the rates of pay vary widely—as is often the case where day work, piecework and apprentice labor all are in vogue—distribution on the direct-labor-hour basis would be more accurate. In that event the total direct-labor hours in any month, as shown by the time cards, would be set down below the total of expense and, by dividing, an expense cost per hour brought out.

There is a third common method of distributing expense—on the machine hour. Under certain conditions this amounts to the same thing as the labor hour, if the division into departments for expense analysis has been made with equipment values strictly in mind. Again, the machine hours are sometimes quite different from the labor hours, as would be the case with a group of automatic machines, furnaces, tumbling barrels or other continuously-operating equipment requiring relatively little attention from labor and irregular amounts of it. The labor cost then is small as compared with the equipment overhead and the labor hours considerably less than the machine hours. Under such conditions the logical basis of distribution is the machine hour.

Getting down to the machine hour is of course very close analysis. More clerical work is involved, perhaps, than in either of the other two methods of distribution described; but where the machine cost obviously exceeds in importance every other element, its adoption undoubtedly is profitable. Every operating expense, even the direct labor, in this case is regarded as incurred on behalf of the equipment investment, to get the most returns from it.

In some plants both the machine-hour and direct-labor plans are followed. General factory is distributed as a per cent of the direct labor, while the department expense is reduced to a machine hour charge. This is on the theory that the general

overhead is incurred chiefly on behalf of the labor, while the department expense is due to the machines.

In other instances, a division is made between the items of expense which will accrue whether the plant is operating or not, and those which cease when production stops or vary closely with the plant activity. This really amounts to making a separate sum of the fixed charges on the expense-analysis sheets and establishing a separate per cent or hourly charge for them. The advantage of this plan is that, in times of stress when the margin of profit must be sternly sacrificed in order to keep the plant running at all, the cost can be figured with only expenses actually incurred added. Taylor called this the *limit cost*. It is the point below which you cannot afford to cut, but by going this low you lose less money than you would if you shut down altogether rather than lower your price. It is the point also which determines whether you should continue making or buy outside.

Expense distribution is thus seen to be an intricate problem. Different methods are not so much alternative as they are adapted to different sets of conditions. In the same plant, often, every method will be found in use, each fitting the requirements in some one or more of the departments. In an ironware plant, for instance, distribution on a material basis proved more equitable for the foundry, on a direct labor basis for the cleaning and machining departments, and also the painting and packing departments; while the machine, or furnace-hour plan suited conditions most nearly in the enameling shops. No plan, therefore, should be adopted generally in any case without a careful study of conditions. However, the underlying scheme is the same in all, and the methods of laying out the expense-analysis sheets herein outlined are generally applicable.

XII

COLLECTING MATERIAL AND LABOR COSTS

IN providing for the proper accounting of labor and material charges, it is essential to bear in mind constantly the fact that you have two classes of charges to assemble. First, the labor and material actually applying on the orders, or the direct charges; and second, the labor and material which are so general in nature that they cannot conveniently be assessed against the cost of any one order, but must be distributed, together with administrative and fixed charges, over all the orders handled in a given period. The latter are indirect charges and make their way into the cost as explained in the preceding chapter.

While the same time tickets and material-issue slips may be employed to report both direct and indirect charges, having a distinctly different form for each class simplifies the work of accounting and cuts down the chances of error. This is less important, perhaps, with the material-issue slips, however, as by a proper system of charge symbols, these can readily be divided. The convenience of both shop and storekeeper certainly is served by having only one kind of slip. Different colors, however, are often adopted to distinguish material issued from different storages, or to distinguish between material jobbed and material processed in the plant. Raw material regularly used in large quantities, as lumber, pig iron, crushed rock, coal and fuel oil, for the issue of which a requisition would only be red tape, is sufficiently covered if reported once a day on a special form by the foreman in charge.

With labor the situation is somewhat different. Usually a

very simple time ticket will answer for the indirect labor, if indeed the time-clock record is not sufficient. The time of supervisors, and clerks especially, needs no other check. Direct labor, on the other hand, requires a more or less complicated form, which carries the order number, operation symbol, piece name and number, and such other information as may be necessary to identify it completely. For direct labor in indirect departments the requirements are essentially the same as for the direct labor in the direct, or producing departments. To make the time tickets of a different size or different color is desirable, however, for reasons already given. If the number of departments is not too great, a color scheme carried through on the time tickets will give all the contrast necessary.

One thing that should always be avoided is to have both kinds of labor reported on the same ticket. If a man does both kinds of work in a day, the best plan is to have him make out a separate report of his time on each, on the proper forms, even though the daily rather than the operation, or job time ticket is used. His two tickets can then be compared with the time-clock record together, but separated for the purposes of cost accounting.

To insure without fail that every dollar expended for labor and material is accurately reported and that the over-all checks with the payroll in the one case and with the total of material disbursements, as shown by the balance-of-stores cards or ledgers, in the other, is the guiding consideration.

HOW TO ARRIVE AT THE COST OF DIRECT AND INDIRECT MATERIALS, WASTE AND SCRAP

OBVIOUSLY it is essential that material be issued only on serially numbered and duly authorized requisitions, with the exception previously noted. And it is just as essential that all material either be kept in locked enclosures in charge of a responsible person, or, if in open storage, be closely supervised by a foreman and only those indicated by him allowed to draw from it. Otherwise material is bound to disappear, to be used extravagantly, and to be accounted for loosely. Close control is essential to correct cost finding. Accurate means of portioning out materials by count, weight, volume or surface

measurement, too, is requisite. Many an inventory has failed to balance with the book records because of liberal measures in stores issue, with the result that book profits when corrected have been diminished to the vanishing point.

Another essential to proper material accounting is standards of consumption, so that the storekeeper may also check the correctness of quantities requisitioned. The tendency is to overdraw and then to be careless with the left-over. Carefully prepared bills of material furnish a check in the case of applied materials. As for materials that class as supplies, or indirect, rating the foremen according to their consumption of such can be relied upon to make them careful to scrutinize every request before they attach their signature in approval. In time, standards can be set even for these, definitely guiding not only the foremen but also the storekeeper.

Direct material that is processed brings up the further question of waste. The amount of material in a finished product is almost never the same as that started with. Of course, the weight of an assembled product is equal to the sum of the weights of its parts; but the parts themselves, through drilling and machining, represent a certain shrinkage from the original volume. Nuts, for instance, are made up from rod-stock. Sawing, drilling, tapping and finishing may remove a third or more of the raw material. The waste, that which can be collected, has only a fraction of the value of the stock. A small percentage can never be accounted for. In order properly to price the material in the finished product, it is therefore necessary to record the weight of the finished good pieces as well as the stock issued against the order, find the ratio between the two and increase the listed price accordingly. The reclaimable waste is a legitimate credit at its scrap value, but seldom is it practicable to carry the accounting into such detail. The scrap is simply pooled with other similar scrap and when sold or remelted is credited to the department or general expense, as the case may be. Jewelry manufacture furnishes about the only exception. Here the material is so valuable that it pays to keep close tab on the waste resulting from each single operation and to charge to the order only the actual amount of material in the finished article plus the unaccountable loss.

Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Sun.
5.30	5.36	5.42	5.48	5.54	6	6.08	6.12	6.18	6.24
6.30	6.36	6.42	6.48	6.54	7	7.06	7.12	7.18	7.24
7.30	7.36	7.42	7.48	7.54	8	8.06	8.12	8.18	8.24
8.30	8.36	8.42	8.48	8.54	9	9.06	9.12	9.18	9.24
9.30	9.36	9.42	9.48	9.54	10	10.06	10.12	10.18	10.24
10.30	10.36	10.42	10.48	10.54	11	11.06	11.12	11.18	11.24
11.30	11.36	11.42	11.48	11.54	12.00 12.30	12.36	12.42	12.48	12.54
1	1.06	1.12	1.18	1.24	1.30	1.36	1.42	1.48	1.54
2	2.06	2.12	2.18	2.24	2.30	2.36	2.42	2.48	2.54
3	3.06	3.12	3.18	3.24	3.30	3.36	3.42	3.48	3.54
4	4.06	4.12	4.18	4.24	4.30	4.36	4.42	4.48	4.54
5	5.06	5.12	5.18	5.24	5.30	5.36	5.42	5.48	5.54
6	6.06	6.12	6.18	6.24	6.30	6.36	6.42	6.48	6.54

DAY **Direct Day Work** NIGHT

Date _____ 191_

Name _____ No. _____

Order No. _____ Part Name _____

Size _____

Operation _____

Pieces Finished _____

Hours _____

Hour Rate _____

Amount _____

7 | A. M. / P. M.

Foreman

Use This Ticket for Day Work

Tally Time Ticket

Date

Department

Order No.

Man's No.

Position

1 Helper's No.

2 Helper's No.

3 Helper's No.

	0 00	1 06	2 12	3 18	4 24	5 30	6 36	7 42	8 48	9 54							
6											Symbol						Time
7											Tally						Total Pc's
8											Symbol						
9											Tally						
10											Symbol						
11											Tally						
12											Symbol						
1											Tally						
2											Symbol						
3											Tally						
4											Symbol						
5											Tally						
6		Total Time		Hours		Tenths		O. K.									
								T. K.									

Fore man's Tally ✓ | Time ✓ | Ent'd. P. R.

FORMS XLVII and XLVIII: These two time tickets were designed to minimize pencil work. The day is divided into six-minute periods, or tenths of hours. Crosses in the proper squares indicate the starting and stopping time on each job. The elapsed time is computed quickly by counting down for the hours and across for the tenths. The upper form is a job time ticket, while the lower is arranged to serve for as many jobs as there are recording spaces to the right. In this case the same cross that serves to indicate the stopping of one job indicates the start of another

Lumber, particularly, furnishes a difficult problem of accounting for waste. In the average woodworking factory, fully forty per cent of the material disappears in the course of production. The most variable and at the same time biggest loss, of course,

occurs at the cut-off saw, because of knots and other imperfections in the wood, which must be cut out. Bad ends yield another loss. The ingenuity of the cutter in sawing to best advantage plays an important part. Then at every stage of the working, until the parts are ready to assemble, the stock is still further reduced by sawing, planing, jointing, mortising and so on. Some pieces will be spoiled en route. The net board feet remaining from all these operations, which you can exchange for customers' money, seldom exceeds sixty per cent of the quantity delivered from the kiln. Many manufacturers, having found from experience that such a percentage is approximately true, never bother to get closer. That is a mistake. Accurate account should be kept of the waste from year to year on every grade of lumber handled. Each grade can then be charged with its proper percentage and incidentally cheap grades will probably be found expensive. More than one woodworker has found it profitable, as the outcome of such accounting, to buy dimension stock, because the percentage of waste on ordinary lumber added more to the cost of the product than the additional price of the sized and selected material.

This in general is the value of a common-sense accounting for waste in manufacturing. Not only do you get closer to the truth in your costs—an essential in a competitive business, but you develop the true economy of your raw material purchases. It is ultimate, not first costs that count.

So proper running records need to be maintained of the waste on every kind of material which cannot be definitely determined by the simple process of weighing, measuring or counting each time, and ratios ascertained, based on average conditions, by which the material price can be increased for cost accounting purposes.

Allowance for scrap and waste from stock can be credited to general expense, or if salable, to the material account. If, as is often the case, a valuable by-product is developed, it is obviously unfair to charge the full percentage of waste to the principal product. The manager will need to exercise his judgment, and be guided by conditions.

Some applied materials, such as glue, lend themselves still less to accurate accounting. A certain amount of this goes

into the makeup of the various articles coated. Another portion is wasted. How much is applied and how much is lost beyond reckoning is indeed a difficult matter to determine. But by recording the amount of glue issued to the department in each month and deducting the quantity remaining in the pots

Distribution of Glue

From	To	Bal. in Dept.	Issued	Left Over	Actually Used	Charge Expense	Charge Direct Costs
6/30/15	7/30/15	50#	400#	40#	410#	41.82#	368.18#

(1) Article	(2) Unit Contacting Surface sq. ft.	(3) Monthly Output pieces	(4) Total Surface Coated (2)x(3)	(5) Percentage of Total	Glue Used — Total	Per Hundred	Estimated Requirement	Efficiency %
A	4	70	280	8.45	34.65	49.50	40	80.8
B	6	130	780	23.45	96.45	74.20	70	94.3
C	8	90	720	22.90	93.55	103.94	100	96.3
D	3	200	600	18.10	74.25	37.13	30	80.5
E	5	180	900	27.10	111.10	61.72	60	97.3
Totals	—	—	3280	100.00	410.00	—	Average=	89.8

FORM XLIX: Consumption of coating materials may be standardized by means of the form shown above. This provides a simple method of recording the quantity of glue used by one department. Starting with an exact measurement of the contacting surface, the information is carried column by column across the page. The figures yield, finally, a standard of economical consumption for the department concerned. Any quantity used above the standard set may be distributed over the product as a direct charge, according to the ratio of contacting surfaces

at the end, the amount used is readily ascertained. Then by multiplying the number of each different kind of product that went through the gluing operation that month by the unit contacting surface in each case, a sum is obtained which divided by the total of all similar sums, gives the proportion of the glue consumption chargeable to each class of articles. It is then easy to find how much glue should be charged against the cost of each article. Coating materials, as japan, paint, varnish, nickel, copper and tin, can be accounted for similarly. If there is too much variance from month to month, the manager can institute an investigation to learn the reason and thus perhaps stumble on cost-cutting possibilities before unrealized. Some-

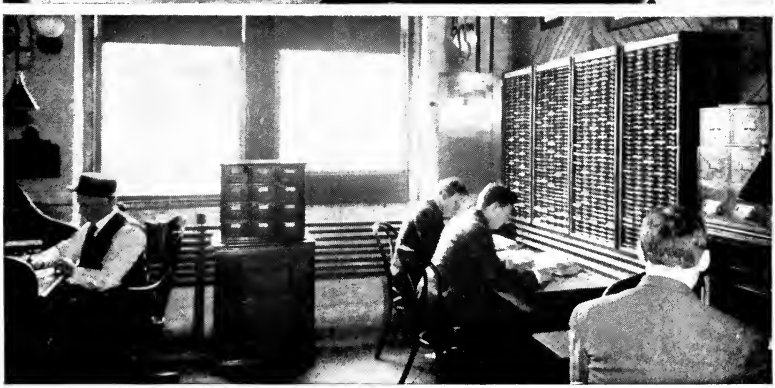
times expense materials, as grindstones and files, can be apportioned on this basis and thus redeemed from the indirect class. To do so is of course desirable whenever practicable.

Evidence of material and supplies issued will at any rate come into the cost department on material-used reports signed by the foremen, or requisition forms signed by the storekeeper and perhaps also the foremen. In one plant the further signature of the superintendent is required, but this seems superfluous except in extreme cases. These reports are first priced and extended, then assorted to order number and expense-account symbols. The prices used are those paid for the actual material drawn from, which are not necessarily the latest prices. A later price is only used after the material on hand from previous purchases at a different price is exhausted. This is not the universal practice, but it is the only safe and sound one. Once the requisitions are priced, extended and sorted, any clerk with an adding machine can in a few minutes find the total cost against a given order number or expense account. A rubber band around each pile of tickets, with the total of these marked on the back or on an attached slip, and they are ready in the one case for the cost-assembly clerk and in the other for the expense-analysis man. Sometimes to furnish a steady job for one clerk and avoid having the cost department jammed with work at the end of the month, an intermediate distribution record is employed (Form L). To this the price-extended material receipts are posted. At the end of the month the sheet is totalled and the sums handled as before.

ASSEMBLING DIRECT AND INDIRECT LABOR BY MEANS OF DAILY AND JOB TIME TICKETS

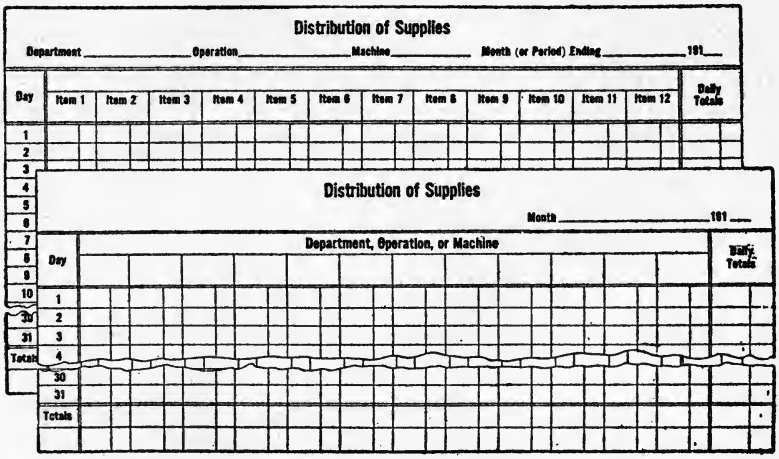
GETTING in reliable labor reports is slightly more complicated than material accounting as it is wrapped up with proper time-keeping methods. A time card for each job worked on by each man is best from the cost clerk's angle. It remains to provide an accurate means of recording the time-started and time-stopped on each job. Having the men do their own timing, as is the practice in some plants, rarely produces reliable cost data and has other bad features. To have the foreman do so

An accurate appraisal of the entire investment is the basis for an accurate cost system. Whether inventorying material or equipment in the shop (above), or filing information in a perpetual inventory (below), accuracy requires that every symbol used shall be simple, definite and brief, if it is to recall the thing for which it stands



Cost systems should fit the plant, not burden it. Two men with comparatively simple equipment handle the cost records in the plant shown below. In the middle, four clerks do the same work with no other equipment than card files. A larger clerical force and more extensive equipment are necessary in the cost department above

also is unsatisfactory in general, as it burdens him with too much clerical work, although some foremen prefer to keep the time on the ground that it gives them a tighter grip on their department. Usually the best results are secured by making the time keeping a separate function invested in a department clerk who either is located at a central point where the men must come


Distribution of Supplies

Department _____ Operation _____ Machine _____ Month (or Period) Ending _____ 191__

Day	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Daily Totals
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
30													
31													
Totals													

Distribution of Supplies

Month _____ 191__

Day	Department, Operation, or Machine	Daily Totals
1		
2		
3		
4		
30		
31		
Totals		

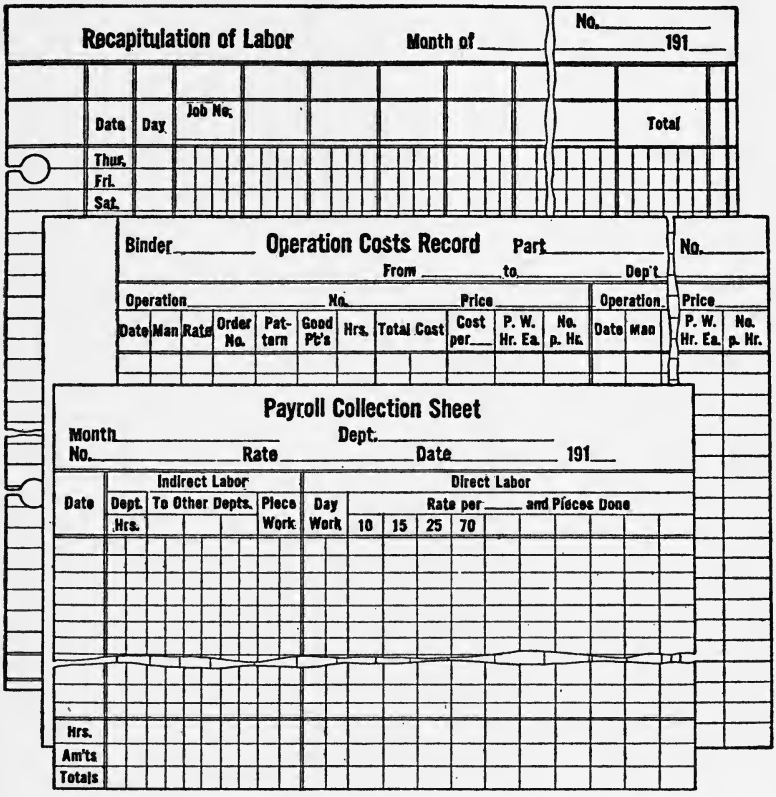
FORMS L and LI: One of these sheets (below) is needed for every department, operation or machine for which an expense-analysis account is opened. To it the material issue slips, or indirect materials, are distributed after they have been priced or extended. A monthly grand total forms the entry to the expense-analysis, or each separate total may be carried forward in detail, if necessary. In the small factory one such sheet with a modified heading (above) will serve for all departments. The departments, instead of the various supplies, are then written in at the top, and a slip for each day then entered as one item

to him at the stop and start of each job, or who spends his time out on the floor, seeing not only that the time is promptly noted in each case, but that each man has at all times at least one job ahead in the clip or pocket at his station.

The advantage of having the time clerk at a central point is that he can then employ some form of time-stamp, even one that automatically figures the elapsed time and thus saves clerical work later on. But unless the trips are few and far between, the time lost by the busy producers in going back and forth will more than outweigh that advantage.

As the job time tickets are collected, they are checked over carefully by the timekeeper to see that all the required informa-

tion is there, then signed and filed in the man's "work done" pocket. Next morning the tickets for the previous day are bundled together and sent to the cost department. Here the payroll clerk first checks them for over-all time and with the clock



Recapitulation of Labor — Month of _____ — No. _____ 191____

Date	Day	Job No.								Total
Thur.										
Fri.										
Sat.										

Binder _____ Operation Costs Record Part _____ No. _____

From _____ to _____ Dep't

Operation _____ No. _____ Price _____ Operation _____ Price _____

Date	Man	Rate	Order No.	Pattern	Good Pc's	Hrs.	Total Cost	Cost per ___	P. W. Hr. Ea.	No. p. Hr.	Date	Man	P. W. Hr. Ea.	No. p. Hr.

Payroll Collection Sheet

Month _____ Dept. _____

No. _____ Rate _____ Date _____ 191___

Date	Indirect Labor				Direct Labor					
	Dept. Hrs.	To Other Depts.		Piece Work	Day Work	Rate per ___ and Pieces Done				
						10	15	25	70	
Hrs.										
Am'ts										
Totals										

FORMS LII-LIV: Above is shown a convenient form for summarizing labor costs by job numbers. Intermediate is a payroll collection sheet, one of which is kept for each man, and is a complete history of his activity. Made up from the time tickets, it is in turn the basis of the payroll. Below is another type of labor record, also posted from the time tickets, but after these have been sorted according to operation and part. Its chief value is in collecting direct and indirect labor costs, which in turn afford a basis for cost control

record, then fills in each man's rate, computes his earnings, adds the premium or bonus made, if either of these payment plans is in vogue, and transfers the total to a payroll collection sheet (Form LIV). The tickets then go to the cost clerk for distributing to the cost summaries.

While the job time ticket is ideal, frequently the jobs worked on by a single man in a day are so numerous that to have a separate ticket for each different job is impracticable. Under such circumstances the next best plan is a ticket a day for each man. Order numbers, name or symbol of article, number of pieces and other necessary information can be filled in by a department clerk if the work is so planned that the sequence in which the orders will reach the machine is definitely known and on record in the department office. All the pencil work the man then has to do is to fill in the time started and stopped on each job. The elapsed time is computed by a clerk in the cost department after the total time has been checked with the clock card by the payroll clerk, who also fills in the man's rating. Then the elapsed times are multiplied by the rate, the result set down and the ticket is ready for the cost summaries as before.

THE JOB TIME TICKET—AN EXAMPLE OF THE EFFICIENCY VALUE OF THE COST SYSTEM

WHEN the job time ticket is not feasible, it is fairly good proof that the plan of manufacturing is faulty. It usually means either that too great a variety of work is being attempted for economical manufacture—or that the jobs are not properly planned and specialized. Far-reaching changes, therefore, may be necessary in either the policies of the house or the production scheme, or both. But this is one of the important benefits of a cost system. In trying to fit the system wrong practices are disclosed, the correction of which is strictly in line with greater efficiency. In proportion as difficulties are encountered in getting accurate time reports upon which to figure costs, wrong conditions may as a rule be assumed to exist, to reform which promises considerable savings.

Again, when the job time ticket is not readily adapted, payment by the piece or any other efficiency plan is seldom practicable. Bonus and premium methods, particularly, are predicated upon the use of a separate card for each operation, and the piece rate works well only when men can be kept busy on the same work for long stretches. Then the job ticket is applicable.

When men are paid by the piece, it is true, time tickets are sometimes omitted. The clock record is assumed to furnish check enough. But this is a mistake. Regardless of how a man is paid, his time should accurately be reported on all jobs if for no other reason than to circumvent the tendency of piece-workers to work or loaf as fancy takes them. While in the plant they should be busy all the time and your time records will show whether or not they have been. You also want to keep tab on their time in order to check their rates. Moreover, it frequently happens that a pieceworker does some day work to eke out his day. A time report on this is essential. Therefore it is on the safe side to have time reports regularly covering the entire activities of each pieceworker.

With indirect labor the situation is somewhat different and a separate ticket for each job is seldom necessary. One ticket for each day usually answers every purpose. Only when indirect labor is done on a piece rate or bonus basis is it necessary to have a separate ticket for each job. Weekly tickets, or keeping the time in a weekly or bi-weekly time book, is in some cases sufficient. It depends on how steadily indirect workers are engaged on the same detail. However their time is taken, the procedure in the office is the same as described for direct labor. The reports are first compared with the clock records, then priced and extended, either singly or in bunches for the payroll period and distributed to the payroll collection sheets or posted to the payroll directly. Finally they are summarized for the expense-analysis sheets.

Another question is in regard to the unit upon which time records are to be taken. Because a product is sold by the pound it does not necessarily follow that the labor cost should or can be found on the same basis. A unit of measurement should be taken which is strictly proportional to the time consumed in processing. In rolling down brass, for example, not pounds nor bars, but the lineal feet over the rolls is the unit which squares best with the time elapsed. Only when similar objects are processed in an identical manner will the number of pieces or the pound basis give accurate results.

XIII

FINDING THE TOTAL COST OF THE PRODUCT

BUILDING up a cost has been discussed in the preceding chapters step by step: first, the analysis of cost into its elements—material, labor and expense; then the computing and tabulation of the fixed charges; next their combination with the variables of expense and the proper distribution of the sum; finally the collection of the material and labor charges. It remains to explain the methods of combining the direct and indirect items to get the total cost of production.

Where these steps have been taken, the cost department then has a variety of information gathered from different sources, and other information flowing to it every day, carrying for its identification the order number to which it pertains. In a plant of any size, it is impossible to maintain an organization which will check or verify all the information thus obtained from original sources, but in two ways a check can and should be maintained which will prove effective, if carefully made.

To the cost department comes a record of all labor charged against an order and all material used on the order. The labor items, in total, should agree with the payroll record. This record is usually taken from the time-clock cards or whatever other method is used to ascertain the time at which an employee starts and stops work.

The other check which should be maintained is on the requisitions for material to apply on work orders. These should regularly be compared with the corresponding bills of material. Requisitions for supplies should also be entered on cards so that a ready comparison can be made of one month with another, or

the totals drawn off for this purpose. Any unusual call for material should be referred immediately to the superintendent for investigation. This also applies to the labor charges on all standing expense orders, such as unloading coal at the power house, loading or unloading of cars, drayage, sweeping, and cleaning.

All plant operations are now divided, according to the records reported to the cost department, as follows:

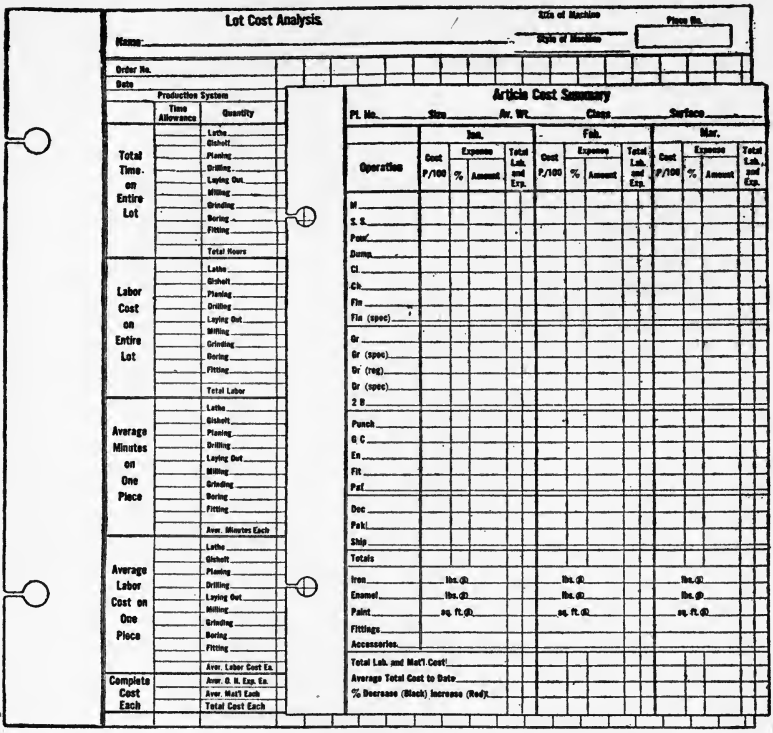
(1) Raw material used in the product, including scrap.
(2) Raw material used as supplies, as well as waste and other expense materials.
(3) Direct labor, including:
    (a) Operatives actually working on material covered by Item 1.
    (b) Assistants not actually operatives, but considered as direct labor and who have their time charged to work orders.
(4) Overhead for special tools, if any.
(5) Indirect labor, including all wages and salaries charged to standing accounts, but not to work orders.
(6) Maintenance charges, including upkeep of buildings and equipment, interest, insurance, taxes and all items not covered elsewhere in this list.
(7) Office expense and selling expense.

Items (1) and (3) are charged to their respective order numbers and form the basic figures, or flat cost of the job. Of course, if piecework prevails, the piece price on an operation is the direct labor cost. Often, however, the same operation is done under both piece and day work, or part of the month one way and the balance the other. Then it is necessary to find the unit cost under day work and average it with the piece price. Moreover, if the set-up is not allowed for on the piece price, the latter must be corrected, or the difference thrown into expense.

BRINGING TOGETHER DIRECT AND INDIRECT COSTS INVOLVED IN PROCESSING MATERIALS

TO THE labor cost at any rate must be added a percentage of itself, or an hourly charge, which will represent the share of that job in all the other activities of the plant as represented by Items (2), (4), (5) and (6). Item (7) is added in

the form of a per cent based on the total thus obtained and completes the cost to make and sell. The share of the office



FORMS LV and LVI: Two different types of final cost sheets are here shown. That in front is adapted for a part or an article cost by operations on steady production and is arranged for parallel entries month by month. To the combined labor and expense cost is added the material cost, giving the total cost to make. The back form serves a similar purpose, but is devised to present more detailed statistical information. The cost is also shown by order numbers and lots, rather than by months, and builds up valuable evidence on the most economical size of lot

chargeable to the factory, however, is preferably handled as an addition to items (5) and (6) as already indicated.

Items (2), (5), (6) and (7) are made up by the cost department into totals for a given period. The best practice favors monthly adjustment of these accounts, although it is frequently done semi-annually or annually.

For the period, whatever it may be, the total for item (5) must be separated into:

(a) Labor directly involved in handling and caring for raw material.
(b) All other indirect labor.

Item (6) must also be separated similarly into:

(a) Fixed maintenance charges on equipment, buildings and other space devoted to storage and handling of raw material.
(b) All other charges.

The total of items (5a) and (6a) for a given period (usually a year) may be taken as a percentage of the total charge of item (1) for that period. This percentage is the first addition to the "flat cost," and is to be added to the total of item (1) which appears on every work order number. Sometimes, as explained in Chapter XI, the handling and storage charges on

Cost of Alterations

Details	Items	Total

Original Cost

A- 1

Machine Cost Record

F. C. No. _____ Machine No. _____

Date Erected _____ Date Inspected _____

Style _____

Special Features: _____

_____

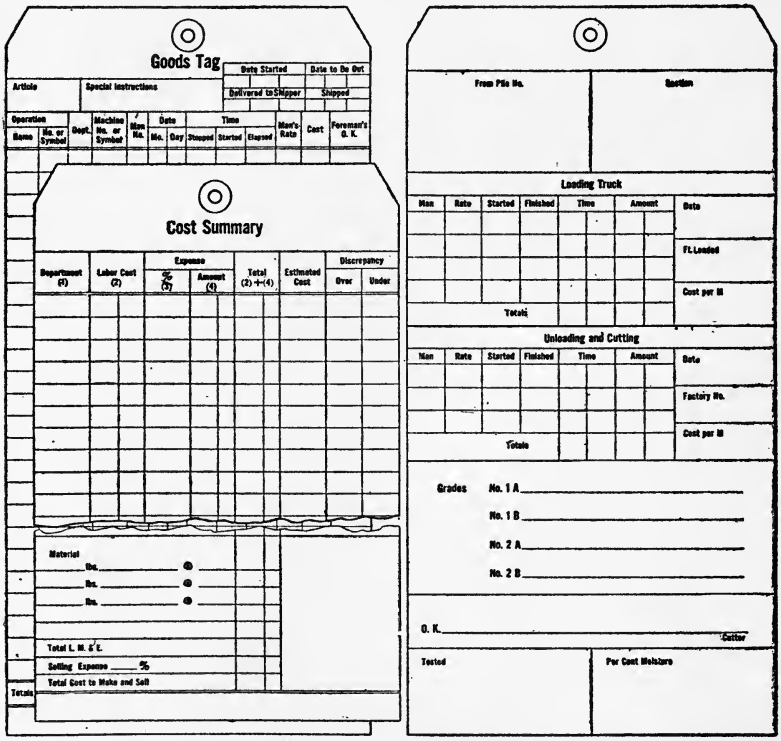
Detail Cost							Summary		
Date	Dept.	Hours	Labor		Burden		Details	Items	Total
							Erection Cost		
							Inspection Cost		
							Labor		
							Burden		
Miscellaneous Material									
Quantity	Description				Amount		Miscellaneous Material		
							Packing Case		
							Shipping Expense		
							Factory Cost		

Remarks:

FORMS LVII and LVIII: This form, in use by an adding machine manufacturer, is unusual in several respects. On the front it gives a complete cost record of each machine produced, while on the back is space for the cost of any alterations that subsequently become necessary. Detail cost, material and cost summary are thus brought together on a single card which is only 4x6 inches

raw material are combined directly with items (5) and (6). While the method here outlined is more exact, the alternative is simpler, as it makes one figure of the burden and that applied to labor as a percentage or added as an hourly charge.

Of course, costs will fluctuate from month to month and, theoretically, the percentages charged against both labor and material will vary. Practically, however, it is usually sufficient to regard the percentage on material as a fixed one. When



FORMS LIX-LXI: Many times the tag which serves to identify and route material in process may also serve to collect the labor costs enroute. At the right is a tag used by a woodworking establishment to collect the labor cost and other data on lumber from the time it is started through the kiln until it leaves the cut-off saw on product order. The tag at the left is employed similarly, but for collecting the cost on material in process. On the back of the same tag all the cost elements are finally brought together

figured once a year, it may be found, for example, that (5a) and (6a) are fourteen per cent of the total of (5) and (6). Therefore, on each month through the year, fourteen per cent of the total of items (5) and (6) is calculated, without the necessity of analyzing them each month. A further per cent is also usually necessary to cover the normal material waste, as explained in

Chapter XI, although this item is often thrown into expense, in order to standardize the material cost (Chapter XII). The loss due to spoilage may be treated as an expense against the department where the loss occurred, or it may be absorbed into the cost of the order by the expedient of figuring the unit cost on the basis of the net good pieces, pounds, feet, or other unit of measurement. Cost summarizing is facilitated, however, if shortages are made good as fast as they occur, so that the full lot comes through. Another way is to start with a surplus which experience shows will offset losses en route and then base the cost on the finished good pieces. Which method is advisable depends altogether on the nature of the order, its recurring frequency, size, and likelihood of loss.

Items (2), (5b), and (6b) remain. The total of these three for any department for the month may be taken as a percentage of item (3) for the same month. This percentage is the second addition to the "flat cost," and is to be added to the total of item (3) which appears on each work order.

If, on any work order, special tools were used, the amount of labor (item 3) applying against that tool must be shown, and the overhead percentage figured on it. This is the third addition to the flat cost. The completed cost, therefore, of any article of manufacture, as shown by its inclusion in the limits of a single work order, is as follows:

Flat cost of raw material (Item 1).
Raw material burden.
Flat cost of direct labor (Item 3).
Amount of overhead for any special tools.
General expense on labor or hourly expense rate.

The total of these five items, taken for each department in turn, is the cost to make.

Manufacturing orders, whether they be to customer's requisition or to stock, so long as they are put through singly or in lots intermittently, are handled as outlined. A single article or lot so small that it can be steered with a route ticket or tag (Form LIX) may have its cost assembled right on the tag. The workmen simply record their time on the tag, the foreman O. K.'ing their entries. On the back an account of the material applied is kept. When the order is completed and the tag is returned to the office, the various entries are checked (the

material against the stock-issue slips, the labor against the daily or job time tickets), priced and extended. The proper per cent to cover overhead is added and the cost is complete. This system is particularly serviceable when the cost of a special order is wanted in the shortest possible time after its completion.

Part Cost Summary

Sheet No.

Part | Symbol

Order No. ___ Lot No. ___ Quantity ___ | Order No. ___ Lot No. ___ Quantity ___

Operation		Order No. / Lot No. / Quantity				Order No. / Lot No. / Quantity			
No. or Symbol	Name	Labor Cost per ___ (1)	Overhead % (2)	Overhead Amount (3)	Total (1) + (3)	Labor Cost per ___ (1)	Overhead % (2)	Overhead Amount (3)	Total (1) + (3)
Totals									

Material

1. ___ lbs. ___

Allowance for Mfg. Waste ___

2. ___ lbs. ___

Allowance for Mfg. Waste ___

3. ___

Total Material Cost ___

Grand Total Cost to Make ___

Assembling Cost Summary

Sheet No. ___

Article ___ Symbol ___

Parts Required			Order No. / Lot of		Order No. / Lot of	
No. or Symbol	Name	No. per Assembly	Unit Cost	Total Cost	Unit Cost	Total Cost
Total Parts Cost ___						

Assembly

Labor ___ $ ___

Overhead ___ % $ ___

Total ___

Painting

Material ___ $ ___

Labor ___ $ ___

Overhead ___ % $ ___

Total ___

Packing

Material ___ $ ___

Labor ___ $ ___

Overhead ___ % $ ___

Total ___

Grand Total Cost

Selling Expense ___ %

Cost to Make and Sell

FORMS LXII and LXIII: These two forms are used together. They are devised to fit built-up article manufacture, where a cost summary is needed on each part and again for the assembling operations. Parallel columns are provided, so that the costs on different lots may readily be compared for purposes of control. At the bottom of the final sheet is space for the entry of the selling expense, so that the grand total represents the total cost to make and sell

On work that is coming through regularly, either in uniform lots or in daily quotas, an order cost serves no particular purpose

and the best method is what is called an operation cost. A card or sheet (Form LXII) is provided for each different operation. If two or more parts undergo identically the same operation, they are grouped on the same sheet. The time or job tickets, after they have been proved with the clock record, priced and extended, are distributed on this record, the amount being divided by the number of good pieces reported, to obtain the unit cost of the operation. Whenever the manager desires to know the cost of any part or article, the clerk draws a closing line and determines the average unit cost. If the order number on each lot is also noted, the manager may at any time find the order cost in a few moments of time simply by thumbing through the several operation records and totalling the amounts on an adding machine, adding, of course, the proper percentages for burden, in each case. If the operation number is also the page or card number, reference to this record, both for recording and cost summaries, is much easier.

More valuable even than the cost-finding feature is the cost control afforded by this record. Carefully kept, it presents an accurate picture of general labor conditions in the shop. Man is shown against man in the same operation; compared with himself at different times; the cost under day work is shown alongside the piece price, if the operation is done both ways. All the fluctuations, in short, are thrown into sharp relief and the manager can take what steps appear wise toward even operation. As a basis for motion and time study, looking to the establishment of standard times and piece rates, for example, this record is invaluable. And when an operation is standardized, the necessity for the continued operation of the record automatically ceases.

FORMS FOR ASSEMBLING COSTS ON PARTS AND ON THE COMPLETE PRODUCT

NO general form can be recommended for the final cost summary sheet, since it will be different for every line of manufacture. It may be very simple or very complicated, depending on the number of operations to which the product is subjected. In a parts business, there will be a summary for each part and

another for the assembled article. If there are sub-assemblies, still a third summary will be necessary, for the final coming-together of all the cost items. The final summaries are always simple, as the assembly is usually made in one operation. They merely itemize the various parts entering into the assembly, with columns for the number of parts required to make one assembly, the unit price or cost and the total value. Parts merchandised are entered according to the price listed on the balance-of-stores records. Parts manufactured on the premises are priced from the part-cost summary, by using the cost of the lot which has been drawn on for the assembly, if the part is not one regularly produced. If the part is a standard stock manufacture, then it is probably better to use an average figure for the cost, except where the material cost is relatively high and is a fluctuating quantity.

At the bottom of the sheet the assembly operation is listed with space for the addition of its proportion of overhead before carrying the total to the amount column. Painting, if any, and packing or crating are added similarly, plus the material required in either case. The total of the amount columns may then be found and is the cost-to-make. To it is added the percentage for administrative and selling expense and the cost-to-make-and-sell is complete (Form LXIII).

The part-cost summaries require, of course, itemizing of all the operations to which the part is subjected, then columns for the per cent of overhead in each case, the amount of overhead, the labor cost and the combined labor and overhead cost. If the overhead is computed as an hourly charge, this charge will replace the percentage and another column will be necessary for the number of labor or machine hours. At the bottom, the total cost of all the operations is placed and the material cost added, giving the grand total cost of the part. The columns may well be repeated across the page so as to afford space for the entry of the cost at different times. This facilitates comparison. At the top of each series of columns the lot number, quantity in lot and order number on which it was executed, are of course necessary. Single article cost summaries are made in an identical manner, with the exception that space for the addition of accessories or

fittings may be necessary, and below, for the addition of the selling expense.

Any of these costs fulfills the demands of the selling and executive departments. To get the fullest value out of the cost information, however, it should be made a vital factor in the shop economy; and by means of proper forms and re-grouping of the data which comes to the cost department, the results should be given to all departments concerned, so that they may have the incentive which comes from a realization of increased efficiency, or the spur of a failure to maintain old standards of economy.

Even of greater value is it that this data be timely and prompt. The shop organization has a proverbially short memory. If the cost department brings down figures for analysis weeks or months after the shop is all through with the job and has forgotten about it, the whole matter, instead of being the aid it may well be, is a worry and a source of irritation.

XIV

PROVING COST TOTALS WITH THE BOOKS

WHEN a contractor has finished his itemized estimate on a contemplated structure, before making up his bid he takes the precaution, if he is wise, to check his totals by certain over-all figures which experience has developed to be roughly accurate. Thus he avoids mistakes in detail—in taking off quantities and in pricing—which, on the one hand, might make his bid so low that he would lose money on the contract, and on the other, increase the total to the point where he would be left high and dry in the competition.

Similarly, the manufacturer should be in a position to verify his cost summaries and know, when he goes into a keenly competitive market, that he is not fooling himself as to his probable profits when he makes prices on the basis of production cost. The way to get this check is to dovetail the factory accounting with the general financial books.

A good cost system does not absolutely require this proof. It can be set up as a thing apart from the ledger accounts, and if the work of analyzing, gathering, tabulating and totalling the cost data is very carefully supervised and checked at every stage, the discrepancy between theoretical and actual profits will be slight. But this could also be said of the contractor's estimating. To conceive of its being done so painstakingly as to be free from error is possible. The last measure of assurance, however, is lacking, and the contractor who would stake his reputation and capital on such estimates, when the over-all check is so simple, could scarcely be called a conservative business man. So it is with factory costs. The human factor must always

be reckoned with and every feasible check or proof applied. When the costs are not required to close through the books, the tendency is to be satisfied with "near-enough." Tolerance of little errors leads to winking at larger ones, and before the

CLASSIFYING THE CONTROLLING ACCOUNTS

Manufacturing Accounts
- Factory Expense
- Materials
- Supplies
- Direct Labor
- Indirect Labor
- Goods Finished and in Process

Operating or Profit and Loss Accounts
- Cost of Goods Sold
- Income from Sales
- Selling Expense

Current Asset Accounts
- Accounts Receivable
- Notes Receivable
- Cash
- Prepaid and Accrued Operating Expense

Current Liability Accounts
- Accounts Payable
- Notes Payable

Capital Accounts
- Capital Stock (Subdivided According to Issues)
- Surplus

Plant and Equipment

Reserves
- Depreciation
- Bad Debts
- Repairs
- Interest
- Retirement of Loans

FIGURE IX: A proper classification of accounts is the first step in laying out an accounting system which will comprehend the entire business. The first group of accounts is the one through which the factory costs clear. This group in turn closes through the second group, where, as the Cost of Goods Sold balanced against the Income from Sales, less the Selling Expense, it gives the profit or loss at the end of each book-closing period. The other groups are self-explanatory

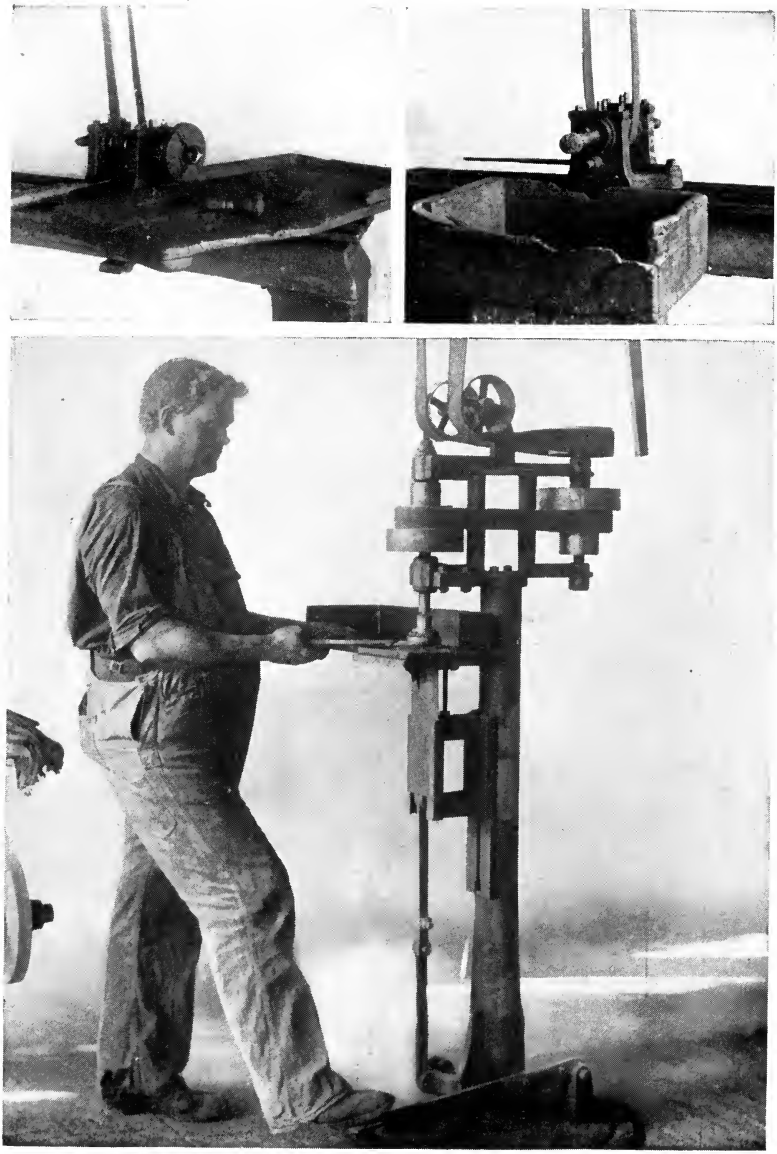
management is perhaps aware of it, the system is honeycombed with inaccuracies and approximations, and its every indication is untrustworthy and misleading. Link your factory accounting with your books if for no other reason than to keep the cost-finding force keyed up to the proper respect for their figures.

HOW PRODUCTION COSTS CLOSE INTO THE CONTROLLING ACCOUNTS OF THE BUSINESS

ACCOUNTS, in the scheme contemplated, arrange themselves naturally in several groups (Figure IX).

The first group—"manufacturing accounts"—is the one chiefly concerned in proving the factory costs, and of these the keystone account is "factory expense." To this account the total

To help some shop officials keep in mind the fact that the cost of a suggested improvement may outweigh its value, one railroad has placed in every shop office signs bearing in large letters the single word, "Cost." Such a policy often leads to the development of devices like that shown below, in which gravity furnishes the required pressure for furnace doors being ground simultaneously



By standardizing operation, standardized material and labor costs become possible. In a steel plant the one best way (below), of polishing nickeled cups was found after the two methods shown at the left and right, above, had been discarded. Formerly, the polishing part of the machine was horizontal and operated by hand. By turning the machine "on end," output was increased 500%

expense of the direct, or producing departments, as footed on the respective expense analysis sheets in any month or period (See Chapter XI), are carried forward as one item and entered on the credit side under the heading "goods finished and in process." The offsetting debits are obtained from what is called a "charge" or "voucher register," to be explained later (Form LXV), and consist of the various items making up manufacturing expense—indirect labor, supplies and fixed charges, the bookkeeping term for which is "prepaid and accrued operating expenses." The amount of these which appear on the charge register is in turn taken; the indirect labor from the "distribution payroll" (Form LXIV), which is simply a summary of the payroll collection sheets mentioned in Chapter XII (Form LIV); supplies, from the material or stores distribution sheets, also mentioned in Chapter XII (Form L), or from the material-issue slips directly; and prepaid and accrued operating expenses, from the sheet of fixed charges, (Chapter X, Form XLIV). If no error has been made, this account will balance—which is the proof of the accuracy of the expense analysis sheets. Both the supplies and the fixed charges could be taken from the expense-analysis sheets, but a better check is afforded by going back to the original records in each case. From the total of indirect labor is of course first deducted the amount of office expense chargeable to selling.

As for each debit or credit entry on any ledger account, a corresponding separate ledger account is indicated, there will also be accounts for supplies, indirect labor and prepaid and accrued operating expenses, which are on the debit side of manufacturing expense, and for goods finished and in process, on the credit side of the same account.

The amount for supplies debited to manufacturing expense will be on the credit side of the supplies account under the heading: goods finished and in process. The debits will be supplied by the inventory as of last date, plus the additional supplies purchased during the month as shown by the charge register. Similarly with the accounts for indirect labor and prepaid and accrued operating expenses. These take their debits, the one from the charge register, and the other from the inventory, fixed-charges sheet (interest and depreciation only) and from

the charge register (insurance and taxes if any are paid during the month). The indirect labor account, of course, closes every month, as the same amount always appears on both sides. For

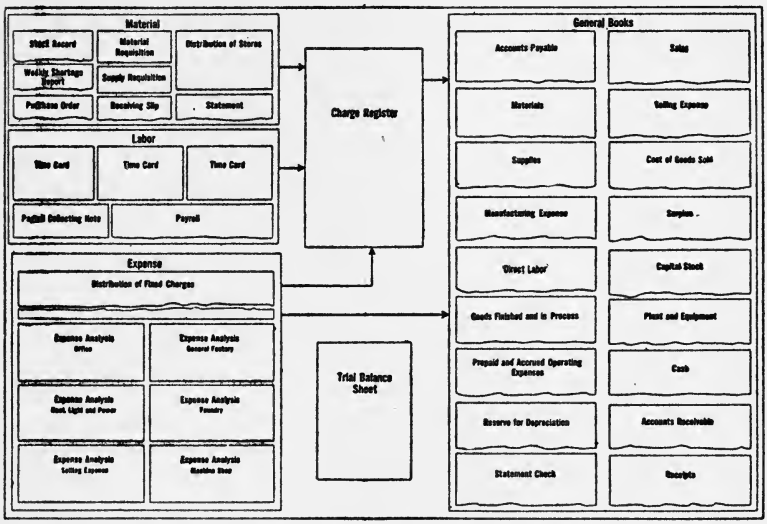


FIGURE X: This chart is a graphic explanation of the cost-keeping system of a large eastern manufacturing company. Forms used in collecting labor, material and expense information are indicated at the left by name. Arrows leading from these forms into the charge register indicate how costs are carried into the general books of the company, indicated at the right. An intermediate step between the two, of course, is the trial balance sheet. Many of these forms are reproduced in facsimile elsewhere in this volume

this reason it is sometimes omitted, and is necessary only for record purposes.

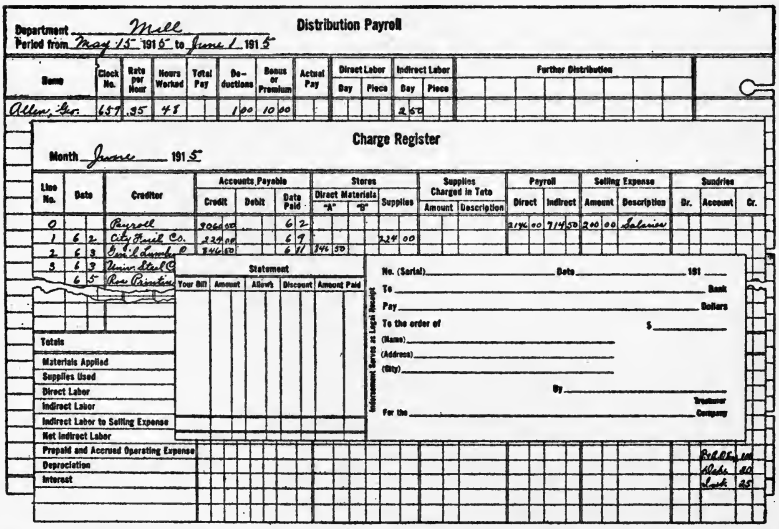
Prepaid and accrued operating expenses should be subdivided on the books into "prepaid and accrued taxes," "prepaid and accrued insurance," and any other operating expenses that are paid in advance. Depreciation and interest, although included in the total of "fixed charges," since they are not prepaid, are handled as separate items, accounts being opened for each. They are therefore brought down as separate amounts on the fixed-charges sheet (See Form XLIV, Chapter X). On the charge register they are entered in both debit and credit columns (under the heading of "sundries"), so that they will not be charged twice. The debits go forward as debits to prepaid and accrued operating expenses, while the offsetting credits are posted to the

credit side of reserve for depreciation and interest.

Goods finished and in process has for its debit the inventory as of last date, the amount of material actually applied during the month, as shown by the stores issued records, the total of manufacturing expense, and the direct labor. The last item is taken from the charge register, which has as its authority the distribution payroll, or from the latter directly. The credit entry is the "cost of goods sold," which is made up from the final cost cards.

The difference between the debit and credit sides of goods finished and in process represents the value which has been added to the material processed during the month.

As before, accounts are also needed for materials, direct labor, and cost of goods sold. Materials account is credited with the


Department Mill — Distribution Payroll
Period from May 15 1915 to June 1 1915

Name	Clock No.	Rate per Hour	Hours Worked	Total Pay	Deductions	Bonus or Premium	Actual Pay	Direct Labor Day	Direct Labor Piece	Indirect Labor Day	Indirect Labor Piece	Further Distributions
Allen, Geo.	657	.35	48		1 00	10 00				2 52		

Charge Register
Month June 1915

Line No.	Date	Creditor	Accounts Payable Credit	Accounts Payable Debit	Date Paid	Stores Direct Materials "A"	Stores Direct Materials "B"	Stores Supplies	Supplies Charged in Toto Amount	Supplies Charged in Toto Description	Payroll Direct	Payroll Indirect	Selling Expense Amount	Selling Expense Description	Sundries Dr.	Sundries Account	Sundries Cr.
0		Payroll	906 95		6 2						216 60	714 50	200 00	Salaries			
1	6 2	City Fuel Co.	320 00		6 9			320 00									
2	6 3	Jos. Edwards	346 59		6 11	346 59											
3	6 9	Jones Hdwe. Co.															
6	6 15	Rex Printing															
		Totals															
		Materials Applied															
		Supplies Used															
		Direct Labor															
		Indirect Labor															
		Indirect Labor to Selling Expense															
		Net Indirect Labor															
		Prepaid and Accrued Operating Expense															
		Depreciation															
		Interest															

Statement
Your Bill | Amount | Allow'd | Discount | Amount Paid

Enclosure Serves as Legal Receipt

No. (Serial) _____ Date _____ 191 ____
To _____ Bank
Pay _____ Dollars
To the order of _____ $ _____
(Name) _____
(Address) _____
(City) _____
By _____ Treasurer
For the _____ Company

Rolls 10
Rods 40
Lock 25

FORMS LXIV-LXVI: A payroll distribution sheet is necessary for every department unless two or more have so few men that they can be grouped on one sheet. It is made up from time tickets or payroll collection sheets. On the charge register is recorded all moneys paid out or owed, and the amounts distributed according to the various controlling and trading accounts operated. The statement check carbons preserve a complete record of all moneys paid out

same amount charged to goods finished and in process and debited with the inventory as of last date, and the amount of materials purchased during the current month, as shown by

the charge register. The difference is of course the inventory entry for the ensuing month.

Direct labor account, like indirect labor, closes each month, the same amount being credited as debited, from the total of

Daily Financial Statement Date____________19___

Bank Accounts			This Year	Loss (Red) Gain (Black)	Last Year
A National		Sales			
Balance Previous Day		This Day			
Deposits Today		This Month to Date			
Total		This Year to Date			
Checks Drawn		Accounts Receivable			
Exchange and Bank Deductions		Balance Previous Day			
		Sales Billed This Day			
Balance This Date		Total			
B Trust and Savings		Allowances			
Balance Previous Day		Cash Received			
Deposits Today					
Total		Net Balance			
Checks Drawn		Accounts Payable			
Exchange and Bank Deductions		Balance Previous Day			
		Invoices Entered			
Balance This Date		Total			
		Debit Memo's			
		Payments Made			
Total Balance		Net Balance			

Receipt Book Month:____________

Date	Item	Cr. Acct's Receivable	Debit Cash	Debit Discount	Debit Allow's	Sundries			
						Account	✓	Debit	Credit
Totals									

Trial Balance, Operating Statement and Balance Sheet Month of____________19___

Name of Account	Trial Balance				Operating Accounts (Balance Only Used)				Balance Sheet (Balance Only Used)			
	Debit		Credit		Debit		Credit		Debit		Credit	
Manufacturing Expense	1080	00	1080	00								
Materials	12000	00	1000	00					11000	00		
Supplies	3000	00	500	00					2500	00		
Direct Labor	2146	00	2146	00								
Indirect Labor	914	50	914	50								
Prepaid and Accrued Operating Expense	250	00	100	00					150	00		
Reserve for Depreciation			20	00							20	00
Interest			25	00							25	00
Goods Finished and in Process	9750	00	2900	00					6850	00		
Cost of Goods Sold	2900	00			2900	00						
Selling Expense	300	00			300	00						
Sales			3800	00			3800	00				
Cash	10500	00	7900	00					2600	00		
Accounts Payable	5000	00	8500	00							3500	00
Accounts Receivable	8300	00	4600	00					3700	00		
Buildings and Equipment	30000	00							30000	00		
Capital Stock			45000	00							45000	00
Surplus			7655	00							7655	00
Totals	86140	50	86140	50	3200	00	3800	00	56800	00	56200	00
					Profit		600	00	Profit		600	00
										✓	56800	00

FORMS LXVII-LXIX: When accounts are simple and entries are kept posted closely, a daily financial statement is possible. In the trial balance shown, balances only are carried forward to the other columns—the balance of the trading accounts to the first and the balance of the remaining accounts to the second. Monthly the totals in the receipt book shown are carried forward to the debit of "cash" and the credit of "accounts receivable"

the direct labor payroll for the month as shown by the charge register.

The cost-of-goods-sold account has for its debit the item credited under the same name to goods-finished-and-in-process.

This is a profit and loss account and does not close. It balances with the sales and selling expense accounts, the difference between the sales and the sum of cost of goods sold plus selling expense being the profit (or loss). Both sales and cost of goods sold should be subdivided on the books into as many accounts as there are classes of goods sold so as to show the profit on each line.

Sales account has only a credit entry, being the amount of goods sold as shown by the "sales book," unless goods recorded as sold are returned and the money refunded. Then it has, of course, a debit for the amount of the returns.

Selling expense, too, ordinarily has no entries on the credit side, and its debits are taken from the charge register, in two amounts—the direct selling expenses as advertising and commissions, and the share of office expense, as given by the office expense analysis sheet.

Before enumerating the other accounts needed, the charge register (Form LXV) may well be considered for a moment. Everything for which money is expended during any month is here recorded and distributed—materials and supplies purchased, payroll, taxes and insurance and other sundry items. This makes it unnecessary to refer to the purchase orders and statements in making up the book entries. First is a column for the line number for convenience in reference; then a column for the day of the month; next a wide column for the name of the creditor ("payroll" is listed as a creditor, because you pay out money for it); fourth is a series of three columns under the general heading "accounts payable," one for the credit, another for the debit if any, and a third for the date the bill is paid. Next is a series of two, three or more columns for "materials and supplies," the separate columns being for different kinds of materials, to correspond with the subdivision of the book account, and for supplies. Then follow columns for direct and indirect labor, next one for selling expense, with an explanatory column; and finally another series of three columns for sundries. One column is for the name of the sundry account, the other two for debit and credit entries, in order to provide means for offsetting the inclusion of interest and depreciation in prepaid

and accrued operating expenses, as before explained.

An additional pair of columns is sometimes inserted to provide for the distribution of such supplies as are not issued on requisition, but simply charged into the department expense as purchased. Power-house supplies as oil, for instance, are commonly so handled. One column is for the amount, the other for the description.

At the end of the month a closing line is drawn below the last entry on the charge register and the totals of the various columns found. That of the first amount column—accounts payable—becomes the credit entry to the current asset ledger account by that name. The totals of the remaining amount columns become the debits to the corresponding book accounts—materials, supplies, direct labor, indirect labor, manufacturing expense, and selling expense.

Below the totals another closing line is drawn and in the space under this the various credit entries to the same accounts are recorded. Thus in the material column will be the amount of material actually issued; in the supplies column, the amount of supplies issued; and in the sundries column the prepaid-and-accrued operating expense items, also depreciation and interest. In the indirect labor column the amount of office expense chargeable to sales will be entered for deduction from the total, to give the proper debit entry to manufacturing expense for indirect labor, while the same amount will also be recorded in the selling expense column, to be added to the total of items shown on the register.

Thus every single book entry originating from moneys paid out is furnished by one record—the charge register.

BALANCING THE CURRENT ASSET AND CAPITAL ACCOUNTS —WORKING OUT THE BALANCE SHEET

ACCOUNTS PAYABLE takes its credit from the charge register, as has been said, while its debit is provided by the cash book, or by finding the total of the items noted on the charge register to have been paid. The credit balance plus the amount brought forward from the preceding month, is the moneys owed, or quick liability.

"Accounts receivable" takes its credit from the amount of cash received, as recorded in the cash or receipt book, and its debit from the sales book, being the value of goods sold. The debit balance plus the amount brought forward from the preceding month, is the moneys due, or "quick assets."

"Cash" takes its credit from the cash book, which is the same amount debited to accounts payable, and its debit from the receipt book. The debit balance plus the sum brought forward represents the amount of cash on hand. This is also a quick asset account.

Accounts are also needed with "capital stock," "plant and equipment" and "surplus"—known together as the "capital accounts." Although these play no direct part in linking up the factory accounting with the general books, they must be reckoned in the balance sheet. The amount of capital stock actually issued is entered on the credit side of the corresponding account, subdivided according to issues; and of surplus as brought forward, on the same side of the surplus account; while the value of buildings and equipment, as taken from the appraisal corrected to date, goes on the debit side of its account.

The balance sheet (Form LXIX) is then made up from all these accounts, both debit and credit being taken off. The two sides should of course balance, which is the proof of the accuracy of the book records. The profit and loss, trading or operating accounts, as they are variously called, may well be grouped together. Then it is convenient to carry a set of debit and credit columns alongside the trial balance columns wherein only the differences between the credit and debit sides of the trading accounts are set down. The total of the credits subtracted from the total of the debits shows the profit, as previously explained.

Still a third pair of debit and credit columns may be added on the same sheet for the entry of the differences only between all other accounts (beside the operating accounts). The two sides of this should also agree when the profit (or loss) just found is added to the credit (or debit) side.

When this method of bookkeeping is followed, payment of all bills by check is presupposed. One check, for instance, should be drawn for the entire amount of the payroll and redeposited to another account if the men are also paid by checks.

Similarly, the estimated requirements for petty cash should be met by drawing a check to its order, entering the item under sundries on the charges register as a prepaid expense and at the end of the month deducting the unused balance. Then, by another check, the amount is brought up to its original figure.

If the statement check (Form LXVI) is employed, as is now very generally the custom, no receipt is necessary from the payee, and the duplicate record, totalled page by page, dispenses with both check stubs and a cash book, so far as the credit entry to cash is concerned. A receipt book (Form LXVIII), however, is then necessary, to afford a means for recording cash receipts.

A "daily financial statement" (Form LXVII), is another possibility afforded by this system of accounting, if the posting to accounts payable and accounts receivable, and the records which furnish the entries for these, is kept up to the minute as it easily may be. This would include on the one hand a statement of the bank balance, shown for each bank with which business is done; and on the other, the standing of the sales—this day, this month to date, and this year to date, and in a parallel column, the corresponding sales the previous year, together with the condition of both accounts payable and accounts receivable, and of notes payable and notes receivable if these accounts are also carried. By providing three columns, the amounts for this year and last can be shown opposite and in the column between, the gain in *black* and the loss in *red*.

With such a statement on his desk each noon, and a corresponding statement covering production, the executive is fortified with a birds-eye view of his entire manufacturing situation. It is his fault, then, if he fails to act on the evidence presented, to keep his entire investment employed in its most profitable directions. And he may rest assured that both the daily and the monthly detailed financial statements are dependable indications of profitableness, inasmuch as his bookkeeping is rooted deep down in his factory accounting, and through proper time-keeping, storekeeping, purchasing and appraisals, accurately reflects real conditions.

Part III

USING COST DATA TO CONTROL OPERATIONS

AUTHORITIES AND SOURCES

FOR PART III

Chapter XV. Contributed by E. A. Baker, vice-president and assistant general manager, Rathbone, Sard & Company, and formerly president of Baker, Woodman & Company, efficiency engineers, and field manager, Miller Franklin & Stevenson, also efficiency engineers; with additional matter by J. W. Wiley, assistant secretary, the Meyercord Company.

Chapter XVI. Mr. Porter here describes methods of standardizing material and labor costs drawn from his consulting work or investigations in the plants of the Hart-Parr Company, Cleveland Automatic Machine Company, Kohler Company, Link-Belt Company, Clark Brothers, Belmont, N. Y., and others.

Chapter XVII. Contributed by Mr. Porter in collaboration with B. J. W. Sayles of the Griffin Wheel Company. Other plants whose practice is included are those of the Hart-Parr Company, Kohler Company, Seymour Company, and Hendee Manufacturing Company.

Chapter XVIII. J. A. Furer, naval constructor, contributes this chapter out of his own experience in both private shipyards and those of the United States Navy.

XV

WHAT COSTS SHOULD TELL THE MANAGER

COST finding methods sometimes seem to be based on the idea that if only enough detailed information can be gathered and this information scattered broadcast through the organization, a fine crop of efficiency can be grown. Efficiency, however, is not a vegetable to be grown. It is a metal which has to be mined or blasted from the solid rock of yesterday's and today's common practice.

In operation some cost methods remind one of a ride in a merry-go-round. They mount a hobby-horse; in a period of dizzy exhilaration, figures flit by in bewildering profusion; the music stops and they alight exactly where they started. They have not advanced the factory a foot, a day or an idea.

Of what use are mere figures? When asked this question, an accountant will offer to prove his statistics by actual inventories and balances. He knows his mathematics are correct. No doubt they are. The question, therefore, may be amplified. Of what use are figures when they are merely correct? Do they say anything? Do they point anywhere? Do they stir the manager to action like a fire alarm?

Figures must of course be correct, but merely being correct is not enough. They should also be a motion picture of the happenings throughout the plant. This picture should portray actual conditions as they are today, not as they were yesterday or last year, and in such a manner that the executive, by means of conclusions unmistakably pointed, can get actual, concrete results.

Cost schemes in many factories merely subdivide the total

outlay among the various styles, classes or units of product. Costs that tell the executive where he is losing money and why, or that point definitely to cost-cutting, hence profit-increasing, possibilities are few and far between. As has been indicated in previous chapters, a cost system, to be worthy of the name, not only must yield figures upon which reliable estimates can be built and profitable sales prices based, but it must also give close control over all the activities of the factory.

While cost systems in general are subject to a number of weaknesses against which the executive must be on his guard, these three errors in using cost figures are of prime importance: (1) the use of an arbitrary or approximate expense ratio, or one based on conditions which no longer exist; (2) too much detail in the periodical, weekly or monthly cost reports which go to the manager; and (3) the toleration of a high cost on some favorite article or operation.

GETTING A SOUND EXPENSE RATIO TO APPLY IN CALCULATING COSTS

TO keep track of current expense properly and to distribute it accurately is admittedly difficult. Accordingly the tendency, following the line of least resistance, is to use whatever expense ratio is available. Last year's expense, for instance, is frequently employed as a basis for figuring this year's costs. The result is not a cost, but a guess, and when it comes to guessing the manager is a far better guesser than a clerk, and, therefore, a good deal cheaper.

Using even the current monthly expense ratio in going after sales is a questionable practice. For the ratio is bound to fluctuate from month to month and if orders are taken on the basis of a low month, when a high month comes along orders taken at the same price will show a loss which may not be offset. The cumulative period percentage is the only safe one to follow, and the last one to date is the right one to use as a basis for the current month's sales. In a seasonable business, the period would cross-section the situation. Where manufacture is practically continuous throughout the year, the period necessarily would be one year.

A complication arises when business depressions are encountered. Then the factory may operate at half capacity or even under. If all the current expense is charged into current cost and the selling prices are adjusted accordingly, they will be so high that no business at all can be secured. Either the price must be cut to a point where a fair share of the obtainable business can be landed, or the plant closed down altogether. There is always a certain portion of overhead expense accruing in a plant, whether it is operating or not. This expense remains the same whether the volume of business done is large or small; and in times of business depressions, where the factory is not operating nearly to the full capacity, it is unfair to saddle the individual product with the total expense. This total expense should be known and reported, to be used from a control point of view, but the expense should be based upon a normal production, and the difference between this expense applied to costs and the actual expense incurred should be charged against profit and loss and not applied against sales. In the same manner, in exceptional business times, when expense ratios are very low, costs should not be figured on the basis of the actual period ratio, but upon the normal operating basis and the difference applied to profit and loss account. The expense ratio is a measuring stick, but in using it to distribute expenses against costs for periods under consideration, rare business skill is essential.

So at all times, if the manager wants his costs to stand up and talk to him, and talk convincingly, they must have facts behind them and he must interpret these facts broadly. Expense facts covering some forgotten period will never control today's operations. Even today's facts may not be used narrowly. Use of costs, no less than calculation of costs, is an art.

CHARTING COSTS IN THE FORM OF PICTURE WRITING

AS to the second weakness, costs, to get results must walk up to the executive's desk and tell their main story free of distracting detail. Brevity, conciseness and logical order are essential. Masses of figures which compel the executive to spend hours in analysis before he can reach conclusions, are expensive, tiresome and soon fail to suggest methods of control. When a

cost report bores a manager, something is wrong with it. It should be as interesting as an up-to-date play. Then the manager will stay down at the office during the evening to look it over.

If a private detective were to tell a factory superintendent that the cost of finishing "A" grade of goods increased last week about two hundred per cent because a large number of men attended the "world's series" games, the superintendent would open his eyes in amazement. If a cost report tells him the same bit of news in the same startling and convincing way, he will be equally attentive.

Too long has the old assumption been cherished that a cost report must necessarily be a lengthy display of tabulated figures. Costs are figures, but their chief value lies in their relation to other figures. It is by comparisons and totals that managers form judgments. Yet even comparisons lose their force if made in too much detail. In a certain factory at one time more than twenty thousand different job numbers were recorded in the cost reports. Final reports, giving the boiled down essence of the whole, never reached the manager's desk. If he desired any information, he had to glean it tediously from the voluminous and intricate records of twenty thousand jobs.

This is a mistake. What the up-to-date manufacturer wants is a commercially correct cost obtained in a practical manner. Such a cost he can use to advantage in controlling his business day by day. Often graphic charts (Figure XIV) which portray the fluctuation and trend of costs in each department are more satisfactory than whole tables of figures. The executive sees instantly whether costs have gone up or down, and why. He immediately starts to strengthen the weak spots. Not until then does he need to summon the details which lie back of the perspective. Cost standards may admittedly be established by direct analysis, but if the manager has his cost data before him in proper form he can the better appreciate the weak points when they are brought to his attention; more than that, he can take the lead in the work of setting up cost standards and no one should be able to judge so well as he the proper order of procedure.

Favoritism is the third weakness in the use of costs. There

is scarcely a manufacturer who has not found himself at one time or another making excuses or allowances for permitting a high cost on some favorite article or operation. Few executives seem able to view their own business affairs with the same calm,

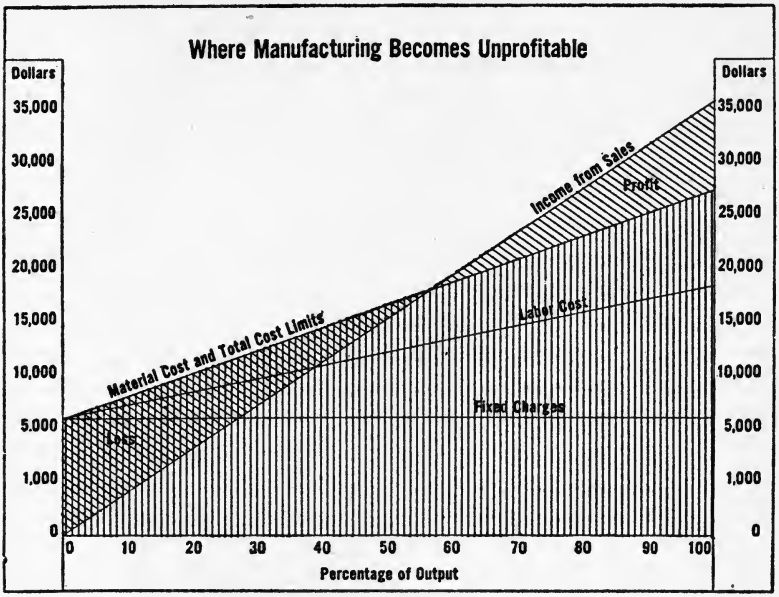


FIGURE XI: All quantity manufacturing is based on selling the output at a fixed price. Total costs, including fixed charges, labor, material and expense are assessed against each unit of product on the basis of this price. When the income from sales fails to cover all such charges, manufacturing becomes unprofitable, beyond this point (58% of output, above) income becomes profit

open mind as they turn upon the affairs of others. No purpose is served by ignoring positive, proved cost returns. The part of wisdom for the manager lies in accepting the discouraging costs and then setting about to remedy the conditions which are responsible. Reorganization in extreme cases is seldom done by anyone on the inside, however. It requires the services of a disinterested individual who has had experience in this kind of work and who can give unbiased inspection and criticism from the broad standpoint of improving the business as a whole.

Not long ago an engineer was talking with a manufacturer about his costs. Though over two hundred different articles were made, costs were obtained strictly on an average basis.

The engineer pointed out that although the books showed a fair profit on the whole volume of business, undoubtedly some of the two hundred articles were being produced at a loss. The manufacturer replied that such might be the case. The engineer then asked him if it would not be a benefit from the control point of view to know the exact cost of the different lines produced.

"If I did know," was the answer, "there would be certain lines I could not sell."

Surprised at this remark, the engineer asked why he could not sell after knowing the exact cost.

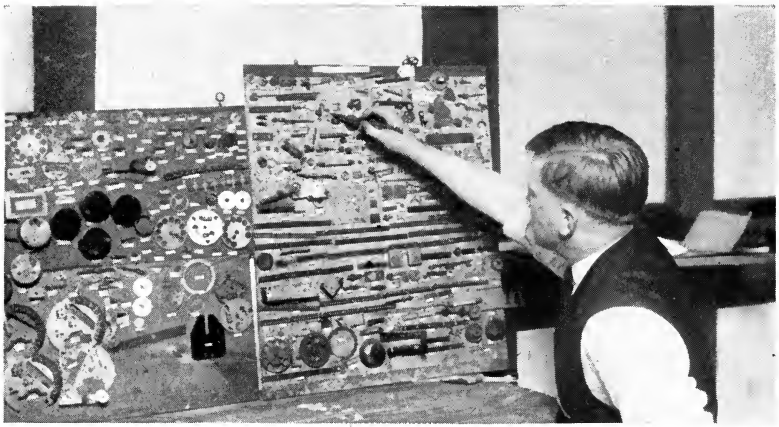
"Every article I produce now, I am selling at a profit," was the reply; "I would not sell goods below cost. Therefore, if a cost system showed me that certain lines were costing more than I was getting for them, I could not sell them."

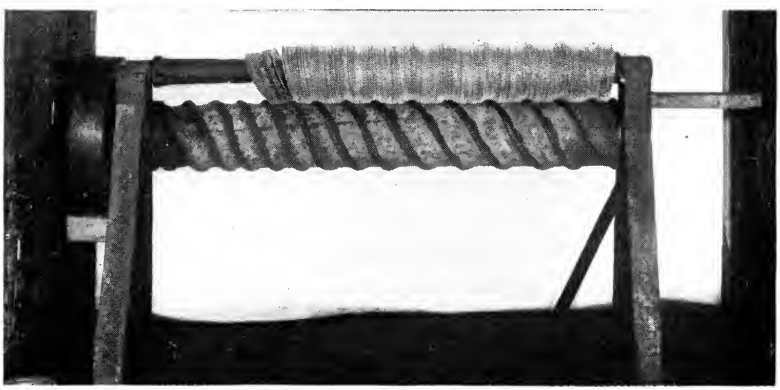
This seems a strange process of reasoning. Yet by similar false logic there are many who deliberately deceive themselves.

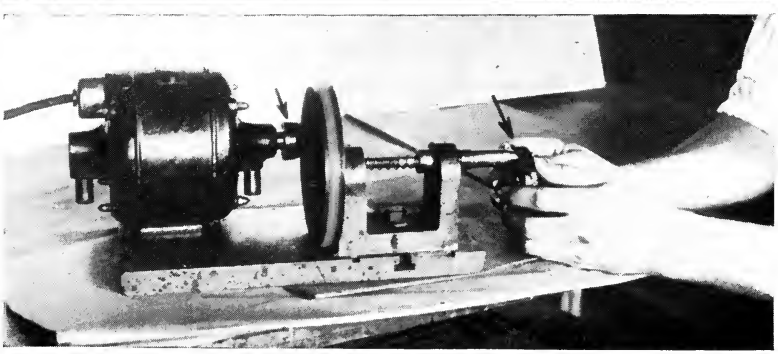
It is a mistaken idea to believe, because a company is making money in total, that it is making money in detail, or even on its most profitable lines that it is making all the money it can. In almost every manufacturing plant certain lines of goods will show a good margin of profit, while others will show little or none. Let the truth be known. The more accurate the figures, the better the business may be controlled. Measures may then be taken to reduce the cost of the unprofitable lines, so that the company is justified in continuing to produce them. If some lines cannot be cheapened, then it becomes a matter of policy whether orders will continue to be solicited and accepted for them.

All this leads to the heart of the whole matter. If costs are to control, they must be controlled. This means the predetermination of costs wherever possible. Material costs can be controlled by eliminating spoiled work, waste and other losses, but the information pointing out these losses must still come in the cost report. The labor cost can be controlled by determining proper work standards and fitting men carefully to the work. And the cost reports are an important aid to this end. The proportion of expense to labor can be controlled if sufficient detailed information is provided and upon this basis standards of expense are set.

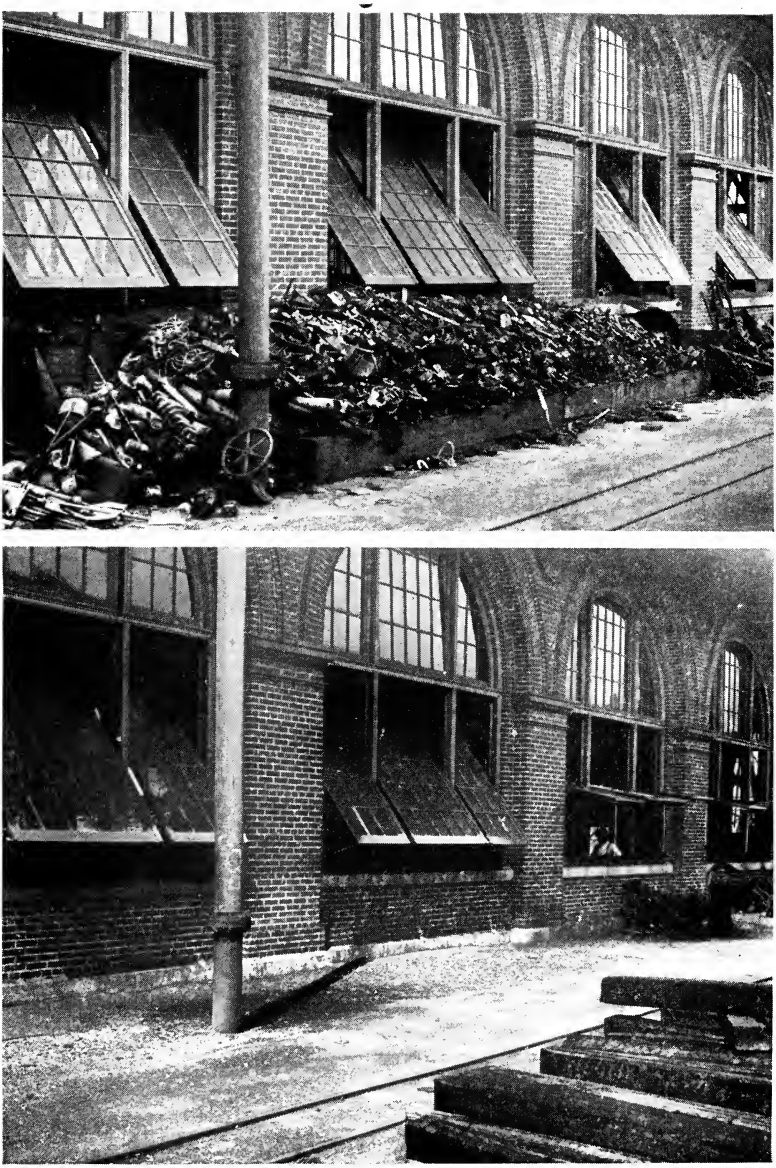
In discussing the value of a cost system designed to give as







Designing a part for a new apparatus, when an old but forgotten part will serve, is eliminated by the telephone company whose stock board of standardized parts is shown above. The device in the middle made it possible to remove burrs from 500 gears in the same time that fifty had been handled. The motor-turned screw driver enables one girl do the work three did formerly



How expense can be cut with a definite gain in neatness about the plant is evident from these before-and-after views taken during a clean-up campaign in a Philadelphia plant. Standardized expense and consequent minimum cost challenge even the scrap pile as an instance of idle investment which should be made productive

large control as possible over material and labor costs and expense, J. W. Wiley, assistant secretary of the Meyercord Company, says: "What do you think of a manufacturer who is satisfied to wait complacently till the close of the fiscal year to know the results of his operations, as to profit and loss? And assuming that at the end of this period the balance sheet does show a profit, of what value is the information so far as being able to determine which products contributed to the profits and which may have been responsible for losses? Is it not possible, and entirely reasonable to suppose, that certain products made handsome profits which compensated for, or counterbalanced the loss on others? The manager who computes his monthly profits or losses on the basis of actual cost, which may be done with amazing accuracy, is on safer ground. One large manufacturer through an adequate cost system succeeded in calculating his profits within a thousand dollars of the amount shown by the annual audit on a business of a million dollars.

"There are a good many reasons for the lukewarm feeling of the average manufacturer with regard to the subject of cost finding, chief of which, I believe, is the idea which seems to be prevalent that cost systems are unnecessary 'red tape' and that they actually are operated at a cost which exceeds the value of the information they furnish. Such an idea is unsound when a system is installed under the direction of a person competent to distinguish between red tape and system, and who knows the dividing line between the cost of elaborating a system and the value of the information made available. It is said that a banker is guided as much in making a loan by the owner's lack of knowledge of the condition of his business as by that with which he is familiar.

"In this connection," concludes Mr. Wiley, "just stop to consider the information that is afforded and the inestimable value of the properly designed cost system. First,—and most important—it should be the basis of reducing costs. Second, it should be the basis of establishing correct selling prices in so far as actual cost and a certain predetermined percentage of profit are concerned. Third, every dollar charged to the payroll and material account should be accounted for in work performed so these two accounts may be credited and manufactured prod-

ucts charged. Fourth, it should be the basis of promoting efficiency in two ways: by compulsion, by virtue of information made available as to workmen's actual relative efficiency; and by stimulating action in order that the inefficiency may not come to the attention of the manager. Fifth, it should furnish the basis for the calculation of monthly profits or losses without the necessity of taking monthly inventories."

So in general a cost system can only produce results when it brings the executive such comparative information as enables him to standardize and intelligently direct improvement in his business. That is control. A management without control is helpless and hopeless. Ability to control future costs comes in a large measure from a continuous knowledge and perspective on past costs, why they accrue, how they vary, and the elements making up the totals.

XVI

STANDARDIZING MATERIAL AND LABOR COSTS

TO reduce costs if possible, at any rate to keep them from rising, is a problem common to all manufacturers. Some may be inclined to underrate the value of a cost system, but all are keenly interested in any scheme that will lower the cost of production and increase profits. Convince these managers that a proper cost system is one means, if not the most effective one, towards this end and they are not slow to want the best that brains can supply.

Cost systems promote efficiency principally in two ways—they show up the fluctuations due to lack of standard methods and they force the management to rectify many wrong conditions in order to get a cost at all. The very fact, too, that a close check is being maintained on every item of expenditure tends to make all hands more thrifty. Thus benefits begin to accrue even before the cost reports reveal to the manager this power of control.

Once the cost reports begin to point unmistakably to weak spots, however, the opportunity for more definite savings arrives. Armed with comparative figures—made the more striking perhaps by portrayal in graphic form—the manager can require from his department managers an explanation for this or that fluctuation. He can, moreover, rate them on their ability to hold department expense uniform. Thus in time, by acting promptly and firmly on the evidence of his cost reports, he can iron out the most flagrant fluctuations. He may even be able to fix some standards.

But standards based on cost data are bound to be tentative

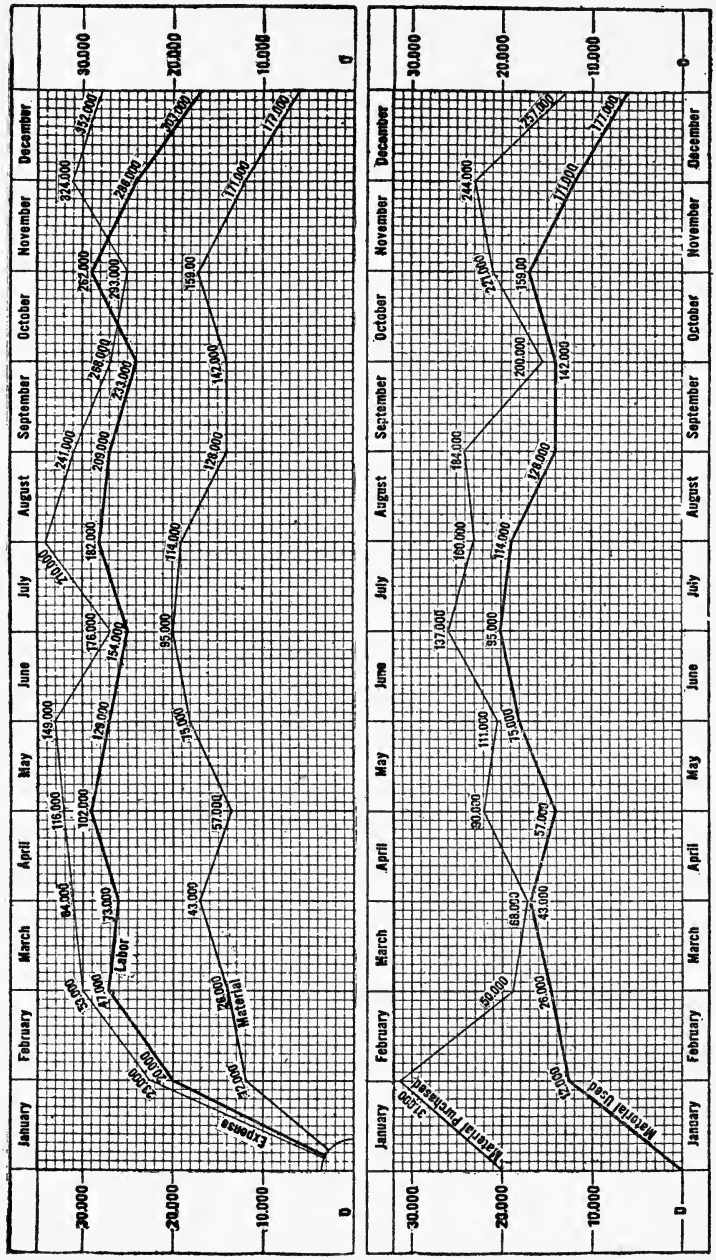
at best. To get down to bedrock it is really necessary to supplement the work of cost analysis with first-hand, scientific investigation. To know that this month's or this day's cost on a certain operation is higher than yesterday's or last month's is useful, but to know how much even the lowest previous figure exceeds the possible limit attainable requires detailed operational analysis. It means motion and time study. It means taking long and definite strides toward scientific, standard conditions of work. For standard costs presuppose standardized operation—and even before the cost system can begin to function effectively as an instrument of control, much work must be done along this line.

A beginning in setting up permanent cost standards can, however, be made at an early stage in the development of a cost system. The guiding principle is to isolate as soon as possible all variables in the cost and then to concentrate on ways of harnessing these variables to standards. This principle, it will be recalled, governed the classification of the elements of expense and the arrangement of items on the expense-analysis sheets. First came the fixed charges and such other expenses as could readily be predetermined and spread over the year uniformly. Then followed the so-called variables, or controllable items of expense.

Typical expense variables are supervision, indirect labor, supplies, power, heat and light, and repairs. These are so obviously indirect charges, which vary with plant activity and efficiency of operation, that the place for them is perfectly plain.

HOW TO SEPARATE STANDARD FROM ABNORMAL MATERIAL COSTS AND REDUCE SPOILAGE

IN this category it is legitimate also to include even the variations in the direct material and labor costs. First take material. This is a definitely measurable quantity. But the pounds, feet, gallons or yards in the finished product by no means equal the number of corresponding units in the raw stock. A certain amount of material always and inevitably disappears in processing. Some of this loss is unavoidable, as the shrinkage in weight and volume of materials containing moisture; the refuse from



FIGURES XII and XIII: Material, labor and expense are graphically compared in Form XII (at the top). Month by month the relation can be seen at a glance, and any unusual fluctuation can immediately be corrected. For instance, in May the expense was $32,000. It dropped to $27,000 in June, and jumped to $34,000 in July. The total values of materials used and materials purchased are shown below. The latter of course starts with an inventory value, $20,000

sawing, jointing, drilling, turning and sandpapering of wood; the chips, filings, shavings and drillings produced in machining iron, steel, brass and other metals; and the unusable ends and soft spots in leather. These may be called normal losses, for which allowance should be made in the material price.

But the loss due to mistakes and carelessness in processing and handling, by far the more serious loss in the average case, should be treated as an element of expense. As early as possible, therefore, a distinction should be drawn between the manufacturing loss, which is normal and constant, and the personal-equation loss, which is abnormal and varying. Obviously a step is thus taken in the direction of control and economy. Material cost is at once standardized. The problem of controlling waste and spoilage still remains, but now it is distinct, as a matter of expense. This arrangement, moreover, is just from the cost viewpoint. Generally speaking, the individual job or lot should bear only its fair share of the burden due to manufacturing errors, regardless of the direct loss in its particular case.

Showing up the abnormal material loss in the expense analysis brings the matter definitely to the attention of the manager. If it is large, he will want to know the reason why. The pressure he will bring to bear on the working force elevates the standards of workmanship. Tracing back for the cause, he may find imperfections in the equipment, or in the manufacturing and inspection methods, or again, in the quality of the raw materials. In this way, many factories have been led to buy on the basis of specification and tests. To control waste, they have found it necessary first to control the quality of their purchases.

Redesigning your product is often a profitable method of establishing a standard cost on material and labor. A Pacific Coast maker of metallic wall cabinets for electrical purposes found that a competitor could sell a similar kind for less than his own factory cost. His shop foreman insisted that he had cut everything to the limit, although his cost was $1.08 against the other fellow's selling price of $1.00. So the owner took the matter into his own hands.

Looking first into the method of manufacture he found that several men would take the flat sheets of steel, turn up the sides, flange the upper edges for the fronts, rivet the corners, drill all

holes and attach the hinges. Other men would make wooden fronts, glaze the doors, attach hinges and locks and mount the doors. Still others would assemble and varnish them. His first decision was to route work in such a way that each man had but one or possibly two processes to handle; the first turning up the sides and flanging the edges, the second riveting the corners, a third drilling the holes, and so on. From the assembler they would go to another room to be varnished and dried, thus keeping the cabinets away from the dirt and insuring better finish.

Then the design was studied and the method of making the corners was simplified, different insulating lining adopted, simpler hinges and locks used and various other details changed. According to the apparent saving, the cost would thus be reduced to 78 cents, a direct saving of 30 cents. When the proposition was put to the foreman he was dubious but agreed to try it out.

The first lot of ten cost $6.90 and further modifications in details and of routing work through reduced the cost finally to 49 cents each.

STANDARDIZING DIRECT LABOR COSTS—WHERE TO CHARGE PREMIUM WAGES

STANDARDIZING the direct labor cost is not so easy. Piece rates are, of course, a solution, since the piece price on any operation can be taken at once as the direct labor cost of that operation. But piece rates if they are not based on standard times may be responsible for a wide variation in the overhead cost and so the adjustment may be a misleading one.

This points the necessity of setting the pieceworkers certain definite performances. Penalizing slow work by a lower rate was Taylor's method of getting uniform output. In this case, the higher rate is taken as the direct labor cost and the difference credited to expense to offset the increased expense cost due to the longer time taken. Taylor also recommended the occasional discharge of a pieceworker for failure to maintain a high level of earnings. This has a wholesome moral effect on the rest of the men. One firm has attempted to meet the situation by paying a graduated bonus annually for sustained high earnings. If, however, pieceworkers are given definite time limits or output

quotas to work to, and lapses from these limits are rigorously discountenanced, reasonably uniform results can be obtained under straight piece rates.

Bonus and premium systems furnish a more difficult accounting problem. If the bonus or premium is added to the day-work wage in figuring direct labor costs, a uniform cost is impossible. But when a bonus or premium is fixed, a basic piece price is always in view. Take this as the standard and charge into expense the excess earnings of those who have failed to average the base price, and credit expense with the savings of those who have beaten the base price. The ratio of these two items becomes then a very good index of the efficiency of the wage-payment scheme. By having it apparent on the expense analysis sheets, the manager is saved referring to any other record. This arrangement promotes control.

Under straight day work, standardization of the labor cost is generally considered impossible. Because of the wide prevalence of this opinion, whenever an attempt to regulate the element of cost is made, day work is speedily supplanted by piece rates or some other of the several so-called incentive plans of wage payment. In many cases, however, it is entirely possible to standardize the labor cost while retaining day work, at least in its outward form. At the plant of the Hart-Parr Company, for example, basic costs have been determined on a great many of the operations. This cost is placed on the work orders. The workman then figures his time allowance in accordance. Thus, if the cost set is seventy-two cents and a man's hourly rate is twenty-four cents, he knows at once that he is supposed to do the work in three hours. In the office an efficiency record is maintained on each man. He is credited with the amount he beats the cost estimate on each job and debited with the amount he exceeds it. Monthly a balance is struck, and if his credits exceed his debits, he is due for a raise in his hourly rate. On the other hand, rates are never reduced, and if a man shows by successive poor showings that he has gone back in his efficiency, other and more suitable work is found for him or he is let out. As in the case of the bonus or premium method of payment, the ratio between the credits and the debits to expense, due to variations

either way from the basic cost, is a good index of the labor policy.

Almost identically the same plan is followed by the Cleveland Automatic Machine Company. The only difference is that a time instead of a cost limit is set on each job, and the men are graded in percentages. The period taken is one month. The average per cent is then found and if it exceeds one hundred per cent, the man is due for a raise in pay. He must reach at least eighty per cent to hold his job. Standard production is fixed by time study and if it seems too high, the men are given the opportunity to demonstrate the fact.

WHAT TO DO WITH SET-UP COSTS AND ALLOWANCES FOR INADEQUATE EQUIPMENT

UNDER any scheme of wage payment, the set-up cost remains. For this usually a definite time allowance is made and the workman is paid either his hourly rate or so much per set-up. Sometimes where the set-up time is insignificant compared to the total time, it is simply ignored or a small allowance made for it in fixing the piece rate or bonus. Unless merged in this way with the operation cost, the set-up cost should be charged to expense, except on special short runs on customers' orders, when of course the amount should be added to the order cost. If at the same time an entry is shown for the interest and depreciation on finished or semi-finished stock, the manager can see at a glance whether merely to keep down the proportion of set-up cost he is justified in running such large lots. When the sum of the two is a minimum, evidently the limit of economy in the size of lots is indicated. Here again control results from the cost reports.

Another frequent complication is the excess cost due to inadequacy of equipment. Varying piece rates are sometimes necessary on the same operation, when it is done on different machines. The lowest or best rate is the one to take as the direct labor cost. The difference between this rate and the higher rates is a legitimate expense item. Appearing in the cost reports, it makes a definite impression on the manager. If it is large, he can at once investigate to determine whether or not an investment in new and up-to-date equipment will be justified. A de-

ficiency in the flask equipment was brought forcibly to the attention of one management in this manner. Molding of small pieces was paid for according to the size of flask. If the proper flask was not available, the foundry foreman used the next larger size. The lowest price, however, was taken as the cost and the excess charged into molding expense, under the heading "Excess Labor Cost Due to Inadequacy of Flask Equipment." Month after month this item ran high. Finally the management was stirred to an investigation which led to a better balancing of the entire flask equipment. In an engine and sawmill machinery plant, where considerable apprentice labor was employed, chiefly because it was thought to be cheap, the excess cost was shown up in the same manner and the result was a reduction in the number of apprentices carried, as well as the scrapping of several old-type machine tools.

Job-work costs, of course, cannot be standardized to the same extent as regular manufacturing. But the same principle holds. The closest and fairest estimate possible should be placed on each operation, and the shop judged in accordance. Excess costs due manifestly to shop blunders, poor equipment or glaring errors in the estimates should not be charged to the particular job, but are a burden on the business as a whole. Thus each job receives only its fair share of the tax, in the per cent for overhead which is added, and the excess costs exhibited in aggregate in the cost reports impress the executive as the amount on an individual order never could. How to develop this method and build up correct estimates on job work is described in a later chapter.

XVII

STANDARDIZING EXPENSE

WHEN all the variations in the labor and material cost are thrown into expense, the expense ratio or charge naturally soars. It has been known to double and even triple in cases. To the manager who has been taught that efficiency is measured by the decrease in the overhead, this phenomenon is ominous. Alarmed beyond convincing to the contrary, managers of the old school whose plants were being systematized, have even called a halt in the proceedings, dismissed the experts, and gone back to their old ways. Their costs were being increased and no amount of argument could persuade them otherwise. That the increase, if any, was only temporary, and that before efforts could be centered definitely on cost reduction, the chaff had frankly to be separated from the wheat—the lost motion from the productive effort—was seemingly beyond their ken.

Overhead goes up not only because in the effort toward standardization of the direct costs, variable after variable is charged into expense, but also for several other reasons. For instance, whole departments may have to be rearranged, machines relocated, old machines replaced by more efficient tools, new machinery and equipment purchased. All this shows in the expense as an extra at first. Then, too, as machines are respeeded and kept more constantly busy, and as hand labor is replaced by machines, power consumption usually rises. In one plant already mentioned, as a result of an improvement propaganda, the power bill increased three-fold. As the direct labor is analyzed, moreover, and the planning separated from the doing and the wasted

time from the productive, the overhead swells still further. But meanwhile capacity is increasing and the amount of direct labor required is being reduced. If the volume of business is sufficient, total costs will be less, even though the overhead ratio has gone up.

HOW TO CHARGE AND CONTROL EXPENSE MATERIALS—FOUR PRINCIPLES TO BE OBSERVED

ONCE all the variables have been segregated and are regularly shown as expense items, moreover, the manager is in an excellent position to exercise control. He can generally make large reductions merely by going over the figures with his foremen. Ofttimes, he can put different supervisors on a comparative basis on some one or more items and thus stir up a healthy rivalry among them.

C. W. Hart, of the Hart-Parr Company, for example, draws up graphs of the consumption of such supplies as cotton waste (Figure XIV). Various departments are shown on the same sheet. The foreman whose curve takes a sharp upward swing in any month, is fairly certain to be called to the office for explanations. Incidentally he sees the curves of the other departments and has the best ones specifically pointed out. The result is a quiet resolve not to be outdone the next month. The consumption for six months by weeks is plotted on the same sheet. The average line from the preceding six months is carried forward and at the end of the period the new average drawn parallel to it. If the factory has done more business the second six months than the first, the averages for the last period will exceed those for the first. But the increase should be approximately equal for all departments. Those that are extreme are then due for special attention. In this way, the manager instills care in the use of all expense materials. On the more important items cost analysis is followed with direct investigation and tests. Thus definite standards are established. Resultant savings have in cases reached as high as seventy-five per cent.

As the principles involved in regulating the consumption of any expense material, these may be stated: First, an attitude of absolute intolerance of careless and wasteful use of supplies

shall permeate the entire organization from manager down to errand boy, but beginning with the manager. Let him have this feeling and be supplied with the proper ammunition by the cost reports, and he will soon enough find means of inculcating the same feeling in his subordinates. Second, working conditions must be standardized, in order to insure uniformity of demand. Third, standards of consumption—targets to aim at—need to be determined carefully. Records of consumption, in as great detail as practicable, and the arrangement of the data in comparative form for analysis, are the first steps in this direction, as has been indicated. The mere fact that such records are being kept in itself is a powerful incentive to economy, which will show, if the figures are plotted, in a steady downward trend

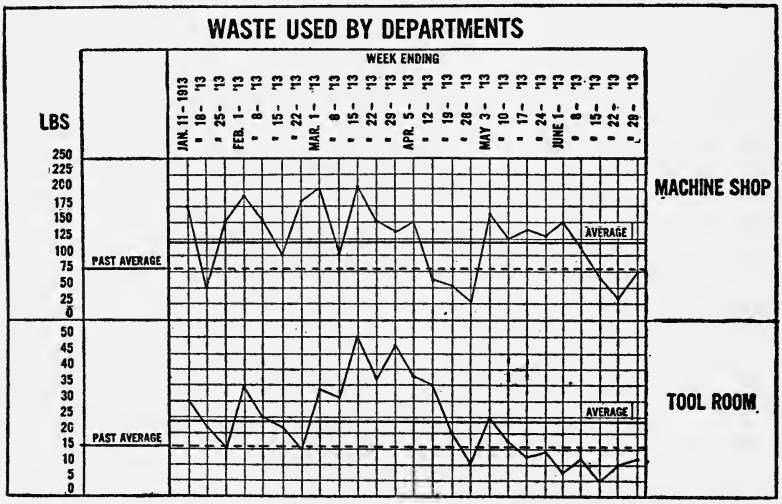


FIG URE XIV: The rate of consumption of expense material is studied by means of graphs at the Hart-Parr tractor plant. Cotton waste is an important expense item in this plant, and above are shown some of the curves indicating its consumption by departments. By means of these graphs, relative savings as large as seventy-five per cent have been made. In the same way, curves are applied to many other items as a means of showing up discrepancies. The graphic method "spot-lights" fluctuations and so is the natural defense against them

of the curve of consumption. After a time, these curves will flatten out. This indicates that normal conditions are being reached.

Fourth, a proper incentive must be supplied to enlist the active self-interest of both supervisors and men in the effort for econ-

omy. Merely by operating an itemized record of consumption by departments so that a foreman may be compared not only with himself at different times, but with other responsible heads of equal rank at all times, a great deal can be accomplished. Publicity of their relative showings is also generally effective in putting supervisors on their mettle. Basing pay and promotion on the improvement they make is a further stimulus. But their fullest cooperation is seldom secured until you directly affect their pay envelopes each pay period. The supreme test of a foreman perhaps is his ability to hold the department expense within reasonable limits. By rewarding him for creditable records you develop his abilities in this respect to the utmost. This plan also applies to the individual workmen, although a scheme of compensation which reaches their self-interest is seldom practicable. To hold the rank and file in line, reliance must be placed on close control over issuance, definite allowances and follow-up by the foremen.

USING COST FIGURES TO CUT DOWN SPOILAGE AND CONTROL WASTE

SPOILAGE and wasteful use of applied materials may be controlled in much the same way as expense materials. As early as possible definite limits should be set for spoilage and avoidable waste, and every effort bent to maintain or beat these on the average. Don't be afraid to set the limits too close. In the average establishment the allowance for both waste and spoilage is altogether too large.

A Wisconsin ironware company mentioned elsewhere in discussing quality work, had been accepting as normal a ten-per-cent foundry loss. The president, however, on a trip abroad, discovered a French foundryman who had reduced his loss to two per cent. Returning, he was receptive to the suggestion of an efficiency expert that no loss is normal and that one hundred per cent good castings was not too much to expect. A bonus scheme was accordingly inaugurated whereby molders making a perfect record any month received a bonus of twenty-five per cent of their total monthly earnings; those registering ninety-nine per cent, a bonus of ten per cent; and ninety-eight per

cent, a bonus of five per cent. In addition, those exceeding ninety-five per cent had their names bulletined on an honor roll. The cooperation of the foremen was also enlisted by paying them a percentage of the bonuses earned by their men. One man hit the bull's-eye the first month, and between ten and fifteen got public mention.

For several months, however, the average per cent of loss remained practically stationary, in fact increased slightly, if anything. This was because inspection simultaneously was stiffened and pieces which before had been accepted, only to require

Casting Defect Code

Defect Number	Defect	Loss		Defect Number	Defect	Loss	
		Molder	Company			Molder	Company
1	Bad Patching	M		22	Pop	M	
2	Bars not Covered	M		23	Poured Short	M	
3	Blow	M		24	Run Out—at Cope	M	
4	Break Down	M		25	Run Out—at Bottom	M	
5	Broken Cores	M	C	26	Scab	M	
6	Broken Pouring Dish	M	C	27	Shaken Out too Hot	M	
7	Burst Flask		C	28	Shifted Pattern	M	
8	Closed Down Wrong	M		29	Strained	M	
9	Core Out of Center	M		30	Strong Facing	M	
10	Cracked Plate	M	C	31	Sweat	M	
11	Cut Cores	M	C	32	Swollen	M	C
12	Defective Ladle		C	33	Thin	M	C
13	Dirty and Rough		C	34	Warped	M	
14	Dirty Cores		C	35	Washed Pocket	M	
15	Drop	M		36	Wash-out	M	
16	Iron Rough	M	C	37	Weak Facing	M	
17	Light Weight	M		38	Wrinkled	M	
18	Loose Clamps	M		39	Wrong Pattern	M	C
19	Loose Cope	M		40	Dirty Plate	M	
20	Melted Chaplets	M	C	41	Abnormal Shrinkage		C
21	No Cores	M		42	Poured from Wrong Iron		C

FIGURE XV: A complete list of casting defects and the corresponding code numbers is given on this page from the "Molders Defect Book" used in the plant of the Griffin Wheel Company. The letters "M" and "C" opposite a defect indicate whether it is classified as a molder's or the company's loss

excessive grinding in the cleaning department to put them in shape for enamelling, were now rejected. "A proper casting should require practically no grinding" was adopted as a standard of inspection. When a molder remonstrated, he was told that if he cared to stand the expense of excess grinding required,

his piece would be passed without further question.

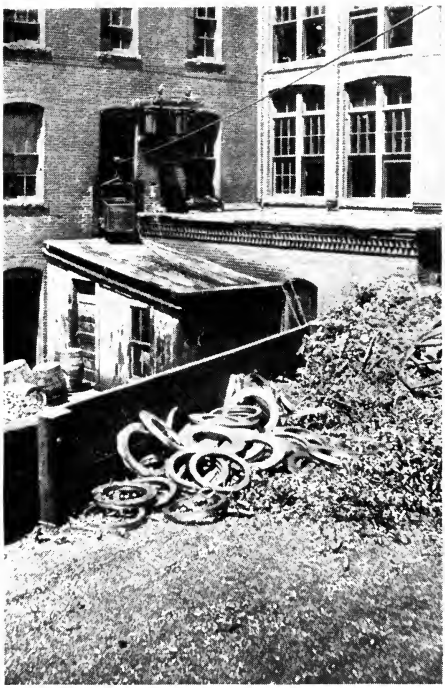
The men, of course, were given every opportunity to state their case and many times the fault for spoiled work was shown to be beyond their control. Recurrent faults not due to the man were promptly investigated and remedied so far as possible. Defective cores, poor sand, cold iron, improperly designed patterns and flasks—these were some of the causes revealed. Not until the worst of them had been corrected was a real leverage obtained on the percentage of loss.

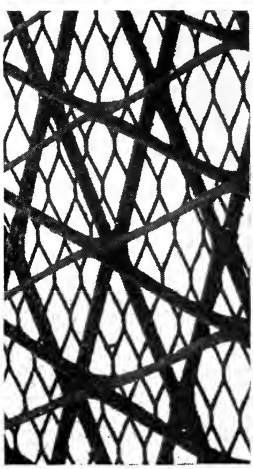
The Griffin Wheel Company, operating a chain of foundries, has been successful in greatly reducing foundry losses through somewhat similar means. Its method, however, has several unique features. A complete classification of foundry defects was first made, consisting of forty-two separate and distinct items (Figure XV). Those due to the men are designated "M;" to the company, "C." Each man, as well as each foreman, is provided with a copy of this code. Pieces lost are reported by "Defect No."

Semi-monthly, losses are tabulated, and as soon as the results are known, an oblong metal tag, three-and-a-half by five-and-a-half inches, is hung over each man's bench, indicating his standing for the period. A loss of two per cent or over calls for a pink tag; of less than two but one or more, a green tag; of less than one, white with a star in the center. A black tag with a gold star in the center indicates a perfect score. Another similar tag is hung alongside the first, upon which the number of the molder's predominating defect is painted in black. The result is keen competition among the men on the one hand to secure a gold star and to keep it continuously over the bench, and on the other, to avoid having their shortcomings advertised to the shop by means of the defect number.

Even more important is the control this system places in the hands of the supervisors. Without consulting any records, or burdening their minds with a knowledge of each molder's peculiarities, they are able, merely by glancing at the tags, to gage each man and to give him specific instruction on the particular point where he is weakest.

The molders are also required to study the "Defect Book" and familiarize themselves with the various defects and their remedies (Form LXX and Figure XVI). Cash prizes are awarded to





Candle-sticks that demand a good price are now made by the Reed and Prince Company from brass that was formerly thrown into the junk heap. The expense of broken windows and other damage caused by flying pieces was eliminated in one plant after the scrap-breaking yard had been penned in by three layers of expanded metal lath

A completely equipped estimating department is here shown. The desk in the middle is occupied by the chief estimator, the desk at the left by his assistant. At the latter's left is the stenographer's desk. Drafting table and adding machine are directly behind the chief estimator. Material specification binders are kept conveniently on top of the card cabinets of data on past performances, which serve as a basis for new estimates

the molder in each shop who makes the best record for six months, and another prize for the man who excels in all the shops taken together. The molders are paid on a piece basis and receive credit only for good pieces when the fault is their own. Company losses, indicating the need for new and better equipment and appliances and closer regulation of supplying departments, are, of course, followed energetically. Net total savings made in any month are made known to the foundry superintendents, not in percentages, but in dollars and cents, which is more effective. The amounts are bulletined so that the men, too, can know the results of their efforts, and this further helps to enlist their cooperation. When, finally, one shop suffers an epidemic of losses due to one defect, the solution worked out is passed on to the other shops for their guidance. Thus a number of levers are operating constantly to eliminate defects and to increase the proportion of good castings.

BRINGING INDIRECT OR EXPENSE LABOR UNDER CONTROL

INDIRECT or expense labor is perhaps the most difficult element to bring under standards. As an item of expense it is in some degree subject to the same methods of control as expense material. A certain portion classes properly as a fixed charge. Of this nature are the salaries of executives, supervisors, inspectors and staff experts, as well as clerks when they are paid on a salary basis. Maintenance work to a considerable extent can be standardized by setting tasks for routine jobs as oiling, cleaning, window washing, and so on, and by executing repair jobs on a schedule precisely as regular operations are handled. Many kinds of clerical work can be put on a piece or bonus basis.

Helping labor presents a somewhat different problem. Some portions of it, trucking for example, may be handled by contract or put on a piece or tonnage basis. But indirect labor in general is essentially a non-standardizable proposition and the supreme test of a management is to hold this variable within close limits.

An interesting solution of this problem was evolved in connection with other reforms already recounted, in an Eastern brass

mill. The proportion of helping labor had become a matter of serious moment. For a few hours each day many men were required to move trucks from the casting shops into the mill, and from the mill in turn to the annealing furnaces and to the scratching room, and from the latter place back into the mill

PLANT_____ DATE_____

Item	Kind of Casting	Pattern No.	Date Cast	Floor No.	Inspector	Defect	Recommended Disposition		Authorized Disposition	Loss Account
							Inspector	Foundry Foreman		
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11.										
12										
13										
14										
15										
16										
17										
18										
19										
20										

37— WEAK FACING

Description:
Sand burned into the surface on either side

Cause:
(a) Not using the proper proportions of seacoal to sand
(b) Not mixing the sand and seacoal together properly
(c) Not using enough facing sand to cover pattern
(d) Iron too hot

Prevention:
(a) See that seacoal and sand is measured in measuring boxes, and that the proper proportions of sand to seacoal are used
(b) See that sand and seacoal are mixed together thoroughly before being riddled
(c) See that pattern is well covered with facing

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FORM LXX and FIGURE XVI: Defective castings are reported on the form shown, at the same plant (See Figure XV). Full details are recorded, and also the recommended and authorized disposition. Another page taken from the Molders' Defect Book is shown in front. Only one defect is given on a page, and below it are brought out the description, cause and prevention

again for final rolling. At intervals, between times, a man or two would be needed at a roll to help load or unload metal. In all, some fifty-odd laborers were kept on hand for these desultory duties, and during more than half the day the ma-

jority stood around in idleness, giving the entire shop atmosphere a lazy, loafing tone which seriously hampered the development of the proper efficiency.

By regrading the passage ways so that gravity assisted in the direction of the heaviest loads, and using shorter and lighter trucks, the force of move-men required was reduced one-half. An area outside the superintendent's office was also partitioned off, fitted with benches and a clerk with a time-stamp placed in charge. Here the surplus helping labor was gathered. By means of an annunciator system, the clerk was kept in instant touch with the rolls and other places in the plant likely to need a man or two occasionally. A man on leaving this enclosure was provided with a card designating the station to which he was to report, and also time-stamped. Thus the foreman requisitioning him could tell whether he had loitered on the way. As soon as he was done with him, he marked the time on the card and sent him back. This card was then time-stamped a second time and if he had loitered on the return, the fact was immediately apparent. By this means the floating force of helpers was cut to twelve. These are kept busy only part of the time, but the "loafing" is now "systematized" instead of unregulated and unregulatable, as before. It took some weeks and a vast amount of patience to get the scheme to working, as many of the helpers quit rather than be corralled in the "bull-pen," as they called it. But the foremen were for it, because the saving showed in their departmental expense reports, and the machine hands, too, eventually fell in line as the convenience of the arrangement made itself felt.

MORE OUTPUT SPREADS FIXED CHARGES AND REDUCES RATIO OF BURDEN

THESE items of expense which in accounting parlance are termed fixed charges—depreciation, interest, taxes, insurance, and executive's salaries—in the sense that their ratio to direct costs varies inversely with the volume of business, are really not fixed at all. But the ratio can be standardized to some extent. Practically the only way is to keep the shop uniformly supplied with work and increase the unit output. The

great difficulty of controlling the ratio of fixed charges in jobbing enterprises, more than any other factor, has led to the wholesale conversion of such shops into stock propositions. Moreover, only a stock factory plant except in a non-seasonable line can wholly cope with the problem. It is to reduce this ratio, therefore, that stock manufacturers whose lines are seasonable are reaching out after supplementary business, to keep the load on their factories as nearly uniform as possible throughout the year, and that even non-continuous industries are organizing on a continuous twenty-four hour basis.

To lower the proportion of fixed charges has also been a main compelling motive in the country-wide movement to increase labor efficiency. Though the apparent object has been to reduce labor costs, back of this is the staggering burden of overhead charges, and often the greater saving by far is in the reduction of the overhead ratio. Indeed, instances exist where labor costs have been increased in order to obtain the other saving and in heavily-equipped industries, labor is worth almost any price in order to secure its full and effective cooperation in the program for more intensive utilization of plant and equipment. Ordinarily, however, though the main purpose may be to lower the percentage of overhead, a notable saving in labor costs also results in spite of the fact that wages are raised.

So far as accounting goes, some standard for the ratio of fixed charges should be adopted as early as possible, even though it be a tentative standard, even a bare guess. When conditions have been standardized and every other variable is under control, the standard can be corrected. After that the actual ratio should regularly be compared with the ideal ratio thus determined, and the general efficiency of the business judged in accordance.

XVIII

HOW TO ESTIMATE ON WORK

SEVERAL years ago an old and well-known ship-building firm failed disastrously. It had been one of the most prosperous firms in this industry during the days of wooden ships. With the advent of steel ships, however, its fortunes began to decline. Its plant had been expanded to meet the new conditions. Its physical location was ideal. Its labor market was the same as that of competitors who are still in the business and who are making money. Its engineering staff and production management were abreast of the art of steel ship-building.

Why did this firm fail?

Many stories are current of the remarkably quick bids which the company made on large repair jobs. Its practice was to send the foremen of the various trades on board a damaged vessel, or to a ship due for an overhauling. These foremen were expected to prepare lump-sum estimates for the work under their cognizance; and they did so—sometimes in half an hour. With these estimates as a basis, the firm made its bids.

This method, judging from the former success of the firm, was sufficiently good for estimating the cost of the comparatively simple process of wooden ship-building. When applied to the more complex construction and equipment of modern ships, the practice of guessing at the probable cost of a job was undoubtedly one of the chief causes for the failure of the firm.

Similar methods in any industry will lead to the same result. By long experience the practical man can, of course, arrive at a point where he is capable of very shrewd guessing as to the probable cost of a job. But the concern that depends entirely

on its foremen for making estimates will certainly lose much business, because some of its bids are too high, and will get other business resulting in loss because of bids too low for profit.

This is especially true of jobbing work, because it is improbable that two pieces of work of this kind will be exactly alike. A man's judgment as to the probable cost of a job, unsupported by analysis of the work involved and the recorded data, is in such cases at the best only a fair guess. In forecasting the cost of work, cost standards meet perhaps the most trying test in their field of usefulness. Cost synthesis is the test of cost analysis and cost control.

HOW TO ORGANIZE AND MAN THE ESTIMATING DEPARTMENT

THE ideal way to estimate the cost of any job is to make a time study of the operations involved, and from it to build up the total anticipated cost. This process, in the case of goods that will be regularly manufactured, is a comparatively simple matter, but obviously impracticable when it comes to estimating the cost of most special and repair jobs.

Although minute time studies may not be practicable for jobbing work, estimates which are far superior to those ordinarily made by the supervisory force of the establishment, however, can be obtained if estimating is made the business of a special department.

The first requisite in starting such a department is to select the right kind of men. In an estimator, the following qualities are requisite: adequate education, general technical knowledge of the work done in the establishment, actual working knowledge of at least one trade, good judgment, and the ability as well as the temperament to work systematically. The last mentioned quality is especially important where cost data are to be analyzed and recorded in such form as to be reliable and readily available for future use. Having found the draftsman or mechanic with these qualities, the manager must still give him time to gain experience.

The department should be started with one man or, at the most, two. The best man available in the establishment should

be chosen, even if he comes higher than the management feels it can pay later on for all of the men constituting this branch of the organization.

First should be taken over the estimating for that shop or division which presents the least difficulty. If attention is con-

Flanged joints, making, 2-1/2", pipe.

Specification	Date	Labor		Material	
Cloth inserted rubber gasket, marking holes & cutting gasket.	From 2-20-14 to 5-18-14				
Setting up bolts.					
Maximum -- for cramped work on ship.			95		
For average ship conditions.			55		
Minimum -- shop conditions.			25		
Units taken from 62 flanges on various jobs.					
Average 5 bolts per flange.					

FORM LXXI: To start a unit-cost data file upon all sorts of jobs, daily reports are kept on 3x5 cards of exactly the work done by each mechanic, together with a statement of the circumstances under which it was performed. If the storekeeper's and estimator's departments are separately housed, material cost cards are necessary. Sometimes estimating may be made best on a weight basis, and cards may be carried for such estimates

centrated on one kind of work, a form of procedure can be developed more quickly which will serve as a standard for the more intricate processes, even if later on the details have to be adjusted to suit the needs of each class of work.

It is not difficult to estimate the cost of applying a coat of porcelain enamel to a steel plate, although the art of the enameler is a highly specialized one. On the other hand, the removal of a twelve-inch gun from a turret of a battleship is an intricate piece of work, although the larger part of it is done by unskilled labor. The former job presents no estimating difficulties, whereas the latter cannot be correctly planned and closely estimated without reliable and comprehensive data, as well as experience on the part of the estimator.

Broadly speaking, the making of an estimate consists of planning how the work shall be done, setting down the operations to carry out this plan, segregating the operations by departments, applying the labor cost to each operation, applying the percentage of indirect expense to the direct cost, making the bill of material needed, and estimating the cost of the material. The estimating department, of course, obtains many plans for doing work from the drafting-room in the form of drawings. Bills of material will also come from this source for many jobs. But whatever the source, all of the steps enumerated must be taken sooner or later in making a reliable estimate.

ACCURATE COST DATA FILES UNDERLIE ACCURATE ESTIMATES

THE foundation on which an estimating department should be built, if it is to work efficiently, is reliable and comprehensive cost data. Such data must cover the cost of the individual operations involved in doing the work. The first thing that will strike the management in transferring the work of estimating to a separate department is the paucity of such unit-cost data. Costs of jobs as a whole, although valuable as a check on total estimates, are of little use in building up the estimate. The cost records which are kept for accounting and auditing reasons usually do not go into sufficient detail to serve this purpose, and are furthermore not so classified as to furnish the information which the estimator needs.

Files of unit-cost data should therefore be started at once by transferring to the new department such meager unit costs as may be found on hand, for the work of the shop which is taken over first. The estimating department then sets about to obtain additional data for itself.

This can be done in a number of ways, the simplest of which, and the one that will yield the most reliable and quickest returns, is elementary time study. By the term "elementary time study," as used in this connection, is meant keeping an exact record of the work done by each workman during the day, analyzing a large number of such daily records, and from them segregating like operations, together with the time taken for each kind.

For example, in one establishment there existed a particular scarcity of unit-operation costs for plumbing and piping work. For several months the leading men in this shop were required to submit daily an accurate report of the work done by each mechanic, together with a statement of the circumstances and surroundings under which the work was done. These reports were checked the following day by one of the estimators, who made notes of any special circumstances or difficulties which affected the facility of doing the work. The data were classified and analyzed daily. After a few months a very complete set of unit-operation costs was obtained.

The maximum, minimum and average costs of each unit were then entered on cards. Unit costs were obtained in this manner for cutting and threading pipes of all sizes, making and breaking joints, both flanged and screwed, removing and resetting plumbing fixtures and valves of all descriptions, lead-lining piping of all sizes, and details entering into plumbing and pipe fitting work.

From these unit costs even a comparatively inexperienced estimator can build up a reasonably accurate estimate.

In making estimates for strictly manufacturing work, especially if work is involved which will have to be repeated a great many times, such as would be the case in manufacturing a large lot of one kind of article, a stop watch time study should always be made. As a side issue it will be found that the investigations made by the estimating department in the pursuit of unit-cost data are very useful to the management in improving the efficiency of production. Such investigations frequently reveal lost motion of all kinds, but especially in providing materials and tools to the mechanics for doing work outside of the shops.

An elementary time study differs chiefly from an ordinary time study in that it indicates the performance which can be expected on a job under the existing conditions of organization and management. As it is the object of the estimator to build up the anticipated cost of a job from data representing actual working conditions in the plant, time studies made in this manner are more valuable to him than those conducted to establish absolute standards, unless conditions are first standardized in accordance with the better method.

Time	Labor: Trades	Estimate		Material: Quantity	Kind	Est. Cost	
	Shop "C"						
	Drain pipes and take measurements	5	60	220 ft.	2½" O.S.D. steel tubing black in 22 - lengths @ .187	41	14
	Break — 35 - 2" flange joints @ .70	24	50				
	Break 15 screw joints @ .10	1	50	780 lbs	240 ft. - 2" lead lining for 2½" steel tubing - 3.25# per ft. @ .05	39	00
	Remove and replace - 18 - hangers @ .45	8	10				
	Lay out and cut - 85 - sections (steel tubing-2½") @ .50	17	50	70	2½" steel flanges @1.05	73	50
15 Days				36 lbs.	½"X1½" steel hex. bolts @ .06	2	16
	Anneal Ends and expand 35 sections @ .70	24	50	15 lbs.	½" hex. nuts @ .06		90
	Fit - 70 - 2½" flanges @ .65	45	50	200 lbs	Scrap brass castings		
	Make - 17 - bends in 13 sections @1.40	23	80		6 - tees - 2½"X2½"X½" flanged - 2½"		
	Lead line - 13 - bent sections @1.80	23	40		3 - tees 2½"X2½"X1½" flanged - 2½" @.15	30	00
	Lead line - 22 - straight sections @1.50	33	00	200sq.ft.	Pipe covering canvas and hair felt @ .06	12	00
	Make up - 35 - 2½" flange joints @ .60	21	00		Miscellaneous from shop stores	2	00
	Shop "D"				Total Material	200	70
	Cast 200-lbs. brass (for 9-special tees) @ .05	10	00				
	Shop "MS"						
3 Days	Machine - 9 - special flanged tees @1.40	12	60				
	Machine and drill - 70 - flanges @ .20	14	00		Indirect		
3 Days	Lag - 168 ft. - 2½" pipe @ .15	25	20	Shop	"C" - 228.40 X 40%	91	36
	Shop "I"			Shop	"MS" - 51.80 X 50%	25	90
2 Days	Galvanize - 168 ft. tubing with flanges - 1600 lbs. @ .015	24	00	Shop	"D" - 24.00 X 270%	64	80
				Shop	"K" - 11.95 X 50%	5	98
	Shop "K"				Total Indirect	188	04
	Rig up for drilling and chipping in 7 - places @ .80	5	60				
	Cut 7 6 dia. holes in bulkheads @ .45	3	15				
	Drill - 64 - 5/8" holes @ .05	3	20				
	Total labor	326	15				

FORMS LXXII and LXXIII: With detailed information in hand concerning labor and material, gathered from such cards as Form LXXI, the actual estimate is made up on a 5x8 form, both sides of which are shown on this and the next page. It is printed on heavy paper and can be filed

The unit-operation-cost data card (Form LXXI) has a column for cost of material as well as of labor. The material column is not generally filled out, and is provided only for unit costs where no great variation in the market price of material is likely. The date of the cost entry is always added, because revisions of cost data must constantly be made to keep step with changes in the wage schedule, improved methods of doing work, and the increasing efficiency of the working force.

Unit costs, as well as unit times, are usually recorded, because the estimator can compile an estimate more quickly from the former than from the latter. The unit cost is merely an extension of the unit time multiplied by the rate of pay of the mechanic or gang doing the work. A brief note, giving the source from which the estimate was obtained—the previous job, time study, or route sheet data—is entered when possible, as this information is very valuable in connection with the investigation of costs that do not agree with the estimates.

No. 880-70 **Estimate** Date Nov. 18-1916.

Ship Item No. 10 Letter C.O. letter October 22-1916

I. O. No. I. O. Wording

Replace about 168 ft. of 2" screwed and flanged iron pipe, forming part of the flushing system, by 2-1/2" lead lined steel tubing as follows:-
Branch supplying captain's and executive officer's bathroom, between frames 94 to 108, under berth deck, port side.
Branch supplying wardroom and warrant officers' baths and waterclosets, on the gun and berth decks, port and starboard sides
Branch supplying chief petty officers' washroom on the berth desk, port side
Branch to ice machine on starboard side

Estimate	
Labor	$326.00
Indirect	188.00
Material	201.00
Total	$715.00
Time	15 Days

Estimated by	Checked by	Inside Superintendent	Material Schedule	Indexed	

vertically like a card. Grouping the estimate on a single sheet simplifies future reference. Even if a few estimates exceed the space available, pasters may readily be added to the back. However, if the majority of the jobs handled are extensive, a larger form is to be preferred

If work is done in the establishment under a piecework or premium system, a copy of the schedule will of course be filed in the estimating department.

If the storekeeper's records are kept in the same general office in which the estimating department is housed, it may be possible to get along without special material cost files. If, however, the two offices are not practically adjacent, it will be found in the interests of efficiency in the long run to provide separate material cost files for the estimating section. For the purpose of estimating, material costs can be kept satisfactorily on 3x5 cards. These costs of course must be revised frequently to keep up with the prices of material carried in stock. If a large job is being estimated, involving the use of a considerable quantity of material which will have to be purchased especially for the job, specific quotations obviously should be obtained from sources.

Many estimates can best be made on the weight basis. A file should therefore be kept of the weight not only of standard com-

mercial materials used in the plant, but also of any fittings and specialties which the establishment uses frequently. A 3x5 card will be found convenient for this purpose.

The size of the estimate sheet will depend largely on the nature of the work done by the establishment. The size should usually be kept as small as is consistent with the use of a single sheet for a single estimate. A 5x8 form is handy (Forms LXXII and LXXIII). Grouping the estimate on a single sheet of heavy paper simplifies future reference. If the estimator wishes to consult a previous estimate, he needs to take from the files only the one sheet. Even if a few estimates exceed the space available on this form, pasters can readily be added to the back. However, if most of the jobs are extensive, a larger form, either of letter or cap size, may better suit the purpose.

SUCCESSIVE STEPS TO BE TAKEN IN MAKING THE ESTIMATE

IN order to bring out more clearly the step-by-step process which is followed in making an estimate, an actual example is offered (Form LXXIII). The job consisted of replacing by lead-lined tubing a worn-out portion of piping which formed part of the flushing system of a vessel.

First of all the estimator traces the run of piping to be replaced. In doing this he makes notes of all the flanges and joints that have to be broken in order to remove the old pipe, of the lengths of new pipe to be fitted, of the new or larger holes that have to be cut in bulkheads and decks, and of the new fittings that have to be made. These data he records chiefly in the form of rough sketches. Notes are also made of the conditions under which the work on the ship must be done, as a guide in selecting the appropriate unit cost from the range of costs for each operation. Next, the estimator sifts out of these notes the work that has to be done by each shop, and enters the items in blank in the labor column on the reverse side of the estimate sheet (Form LXXII). He then consults the unit-cost data file and applies appropriate unit costs to the operations.

To go further into details, take the operation of making up the pipe flanges on this job. The estimator's notes show that there

are thirty-five two-and-one-half-inch flanges to make up, six of which are located among other pipes and are therefore not readily accessible. The remaining twenty-nine are noted as having average surroundings. Turning to the unit-cost data file he

To:	Master Route Sheet	Date
I O.	Brief of Job	
Plan No.	Replace 2" iron pipe of flushing system by 2-1/2" steel tubing as outlined in detail in Section 1 below	
Date to Start		
Date to Complete	Approved Superintendent	Completed

Section No.	Section	Shop	Date to Start	Date to Complete
	Replace about 168 ft. of 2" screwed and flanged iron pipe, forming part of the flushing system, by 2-1/2" lead lined steel tubing as follows:			
	Branch supplying captain's and executive officers bathroom, between frames 94 to 108, under berth deck, port side.			
	Branch supplying wardroom and warrant officers' baths and water closets, on the gun and berth decks, port and starboard sides.			
	Branch supplying chief petty officers' washroom on the berth deck, port side			
	Branch to ice machine on starboard side			
	Galvanize about 168 ft. of steel tubing after flanges have been fitted by shop "C"			

FORM LXXIV: When the job is authorized, a master-route sheet is prepared, and a copy is sent to each department concerned. This form carries spaces not only for the "date to start," and "date to complete," for the entire job, but also for the starting and finishing dates for every operation

takes out the card (Form LXXI) for "Flanged Joints, making two-and-one-half-inch pipe." The method of obtaining the unit costs given on this card has been explained.

Three units are given in this case. This is because the cost of making up a pipe joint varies considerably, depending on its location. If the pipe-fitter must work in a cramped space in a nest of other pipes, the cost will naturally be much higher than if the work is in the open. The latter cost will again be higher than making up a joint at a bench in the shop. There are few operations which are so affected by conditions as are those involved in installing pipe. Many of the unit data cards for other trades will contain only one entry. In this case the estimator applies an average estimate of sixty cents per flange to this operation.

In case the work involved in performing an operation is not clear-cut, the estimator must use judgment in selecting a unit rate between the maximum and minimum to fit the conditions. Actual experience at the trade is of course valuable to the estimator in such cases, but is not essential if the unit-cost data are comprehensive and reliable.

Repair work of this kind always, however, presents some uncertainties to the estimator. In doing this particular job, for example, a number of flanges may be found with badly corroded bolts which cannot be backed out readily, or which may even

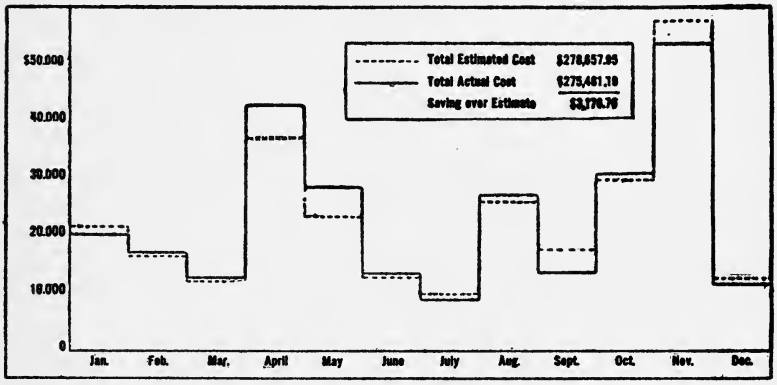

FIGURE XVII: How closely the estimate and actual costs check in one instance where the method of figuring described was used, is here graphically shown. Between actual and estimated costs there was a total difference for the entire year of only slightly over one per cent

have to be drilled out. A few such unforeseen difficulties may be the cause of excessive costs on several operations. The method by which the unit-cost data was obtained, and the averaging effect of estimating by operations do much to iron out such irregularities.

There is, of course, less uncertainty in the case of strictly shop processes. For example, expanding the pipe ends into the seventy flanges is a perfectly definite operation, the cost of which will deviate only because of some quite unusual contingency, or because the mechanic's output differs from that on which the estimate was based.

It will be noted that the cost of galvanizing the pipe is estimated on the weight basis. In the same manner the cost of

the special tee castings is estimated on the per pound basis. The weights of both these items are quickly taken from the weight data file already mentioned. The weight data file is invaluable to the estimator; he uses it constantly, not only for estimating the cost of labor but also for arriving at material costs.

The estimator sets down the material needed under the material column (Form LXXII). After having completed the list, he consults the material cost files. If none of the items are in excess of quantities ordinarily carried in stock, a special quotation need not be obtained from the trade.

Next the labor estimate under each shop is summarized and the indirect expense percentage for that shop applied to it. The form which the estimate for indirect expense takes is evidently dependent on the cost system used by the establishment. In any case this part of the estimate is simple, so long as trustworthy estimates have been made of the direct expense for labor and material.

The total estimates for labor, material, and indirect charges are now summarized on the front of the sheet (Form LXXIII). A summary of the job is typewritten in the same place, in the front of the sheet, as will be noted.

After the estimate has served its purpose it is returned to the estimating department, and is indexed on 3x5 reference cards. Old estimates are frequently referred to for the purpose of checking new estimates. By glancing through an old estimate, even if it is not directly applicable to the work in hand, the estimator often avoids overlooking some operation, or some incidental shop work which is not altogether obvious.

When analyzing the notes and segregating the work by shops, the estimator makes out a route sheet, giving in summarized form the work to be done by each department in carrying out this job. The master route sheet is shown in Form LXXIV. When the job is authorized, a copy of this sheet is sent to each department having work to do on the job; and thus the work is routed as planned by the estimator. The production clerk who prepares the instructions to the shop for doing the work can do so only after thoroughly familiarizing himself with the job and planning how it shall be done. This the estimator has to do in order to make the estimate. It therefore saves time and money to have

this man simultaneously prepare also the instructions for the guidance of the shops.

The actual cost of every completed job, summarized by shops, is sent to the estimating department, and is compared with the estimated cost. These comparisons not only serve to check up the accuracy of the estimators, but frequently bring to light errors in cost keeping and inefficiency or carelessness in the shops.

A monthly report is made of the percentage variation of the estimated costs from the actual costs. This comparison is also made separately for the work of each estimator, and is a reasonably fair measure of the estimator's efficiency. Disagreement between estimated costs and actual costs may, of course, be due to either one of two causes or both combined; namely, inaccurate data and estimating or failure on the part of the operating departments to duplicate the output indicated by the unit costs in making the estimate.

The comparison of the estimated and actual costs is also recorded graphically (Figure XVII). Despite apparent fluctuations due to charging jobs into the months when completed, the total of actual production costs in this case differed from the total estimated costs for twelve months by only slightly over one per cent. Such a result is a shrewd test of the entire production and cost system, and indicates standard conditions interpreted in sound operation data.

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